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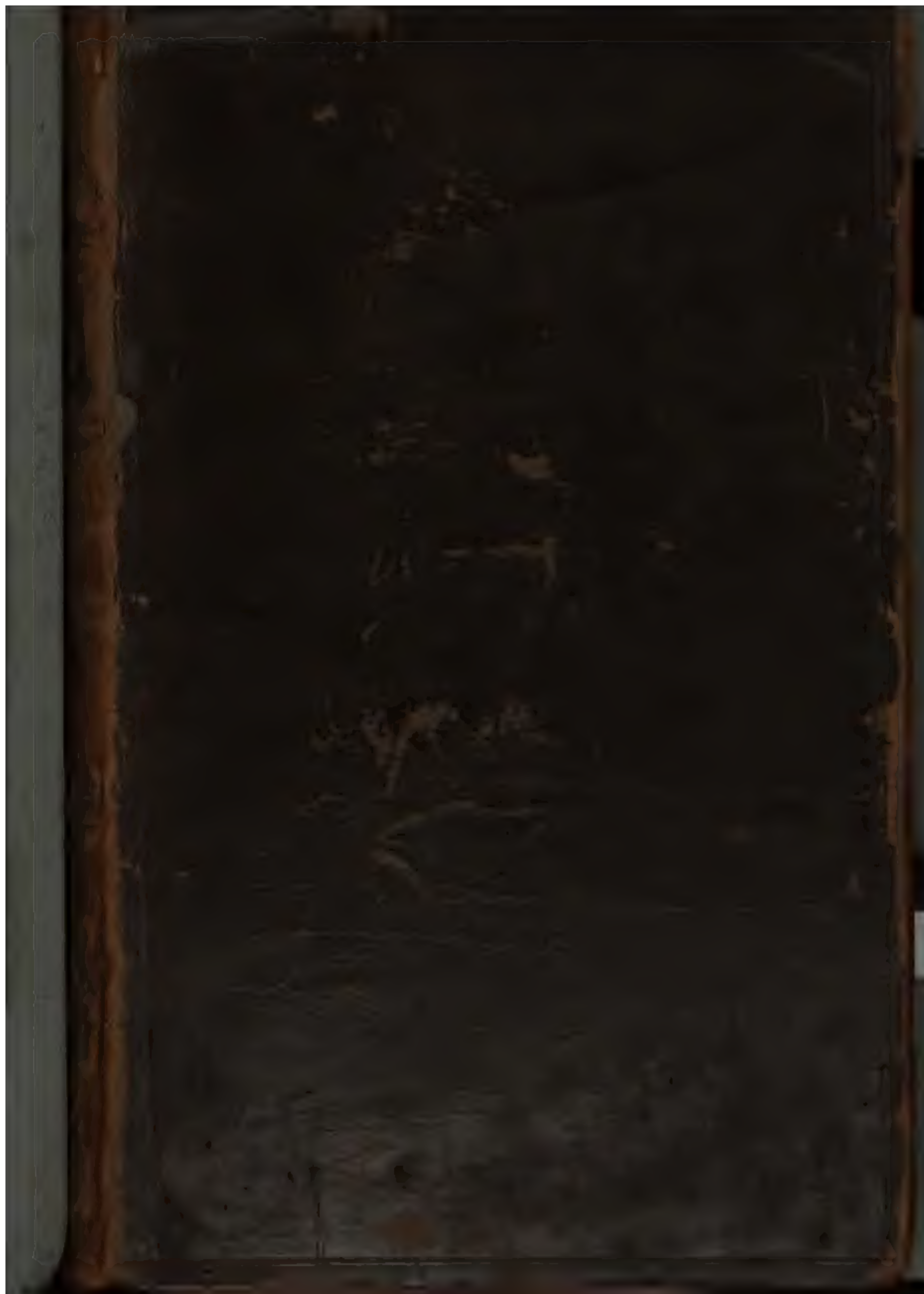
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XXVI







**A**  
**GENERAL SYSTEM**  
**OF**  
**CHEMICAL KNOWLEDGE,**  
*&c. &c.*



A  
**GENERAL SYSTEM**  
OF  
**CHEMICAL KNOWLEDGE,**  
AND ITS  
**APPLICATION**  
TO THE  
**PHENOMENA OF NATURE AND ART.**

---

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor  
of Chemistry at various Public Establishments, Member  
of many Academies, &c.

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IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES IN LARGE FOLIO.

---

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

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VOL. IX.

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A  
S Y S T E M  
OF  
CHEMICAL KNOWLEDGE.

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EIGHTH SECTION.

*Of the Animal Substances.*

FIRST ORDER OF FACTS.

*Generalities respecting the Structure and the  
Composition of the Animal Substances.*

ARTICLE I.

*Of the Structure of Animals.*

1. **AS** I have constantly proceeded in the examination of the chemical properties of natural bodies from the most simple to the more compounded, it is necessary that I should place the animal matters after the vegetable, because they are of a more complicated order of composition. Accordingly their analysis being more difficult, is less advanced, and the results that are drawn from them are less numerous and less certain.

Whatever differences are observed between these two classes of objects, there exists, however, infinitely more relations between the animal and the vegetable substances than between the latter and the fossil matters that have been treated of before them; on account of these analogies the animal matters shall here be considered in the same manner as the vegetable, though with fewer details, as their history is less complete. I shall comprehend all that appertains to their chemical properties under four orders of facts.

The first shall present what is requisite to be known concerning their structure and their general properties both as living bodies and as particular compounds, in order to render the exposition of their chemical properties sufficiently intelligible.

In the second order of facts I shall exhibit the whole of their general chemical characters or the series of their distinctive properties discovered by chemical instruments.

The third order of facts shall be devoted to the history of the chemical properties of each particular animal matter.

Lastly, I shall refer to the fourth order of facts which will terminate this section, the applications of the chemical properties, both general and particular to the exercise of their functions, and to the bases of physiology or physics.

2. The



2. The first fact, which, as one of the most remarkable, strikes in the most forcible manner the mind of every observer who compares the animals with the other natural bodies, is their existence as subordinate to that of the vegetables. There is no one who does not conceive that without the plants no animals could exist, and that it is from them that they derive the nourishment which the mineral substances cannot afford them. Thus the vegetables, considered with respect to the rank which they occupy in the scale of beings, and to the relations which exist between them and the other productions of Nature, are placed in the middle between the fossils and the animals. They borrow elements from the first, they combine them three and three by the power of vegetation; they prepare by the aid of this combination the alimentary matter for animals, they draw from the bosom of the earth substances which they bring to its surface, and which they assimilate in such a manner as to render them proper for the support of animal life: they can exist without the animals, but these cannot exist without them, and if they are not posterior to them in their formation, they can only be their contemporaries.

3. It follows from this consideration, that as the true problem of the nature of the vegetable substances compared with the mineral matters consists in the formation of the former at the expense of the latter by the vegetative

B 2

power,

power, that of the knowledge of animal substances compared with the vegetable must be comprehended in the investigation of the conversion of the latter into the former. An animal of a given weight grows in a proportion also given, and in all its organs at the same time. The augmentation of bulk which it experiences can proceed only from the vegetable matter which it adds to its original weight. This single fact well ascertained proves incontestibly that the vegetable substances is converted into its own body, and becomes animal substance by a power innate in the body of this animal, a power which is termed *animalization*; and it shows at the same time that it is by discovering the laws, the phenomena, and the causes of this conversion, that we shall be able to acquire a knowledge of the nature of the materials which compose its body.

4. In order to acquire this knowledge, so very difficult to be obtained, and with respect to which we have hitherto only a few data, it is sufficiently evident that it is indispensably necessary we should first know how the animals are constituted, or organized, especially in comparison with the vegetables, and this is what I here term their structure. Rapid and general notions upon this subject will be sufficient for our inquiries. Naturalists define animals as living organized beings, which change their situation, move themselves, transport themselves through space, and are endowed with sensibility:

bility: they distinguish them sufficiently from vegetables by the two latter properties; but this very loose distinction does not fulfil the purpose that is to be attained. A number of other still more striking characters also distinguish animals from the vegetables; the external and internal forms differ much in these two classes of organized bodies. A slight sketch of these characters must precede and illustrate the study of their chemical properties, as has been done with respect to the vegetables.

5. The body of animals resembles that of vegetables only in a very few species. We find it divided into different regions or parts of a very different structure, especially in the best organized and most perfect animals. Of these, are particularly distinguished the head, the trunk, and the extremities.

The first, including in the cranium the important organ of the brain, and the origin of the nerves, bearing outwardly the principal organs of the senses, establishes a direct communication and re-action with all the external objects by the eyes, the ears, and the nostrils. The cavity of the mouth, which is placed in it, conducts to the organs of digestion and of respiration, and begins each of these functions.

The trunk composed of vertebæ supports a first osseous muscular and membranous cavity, in which are lodged the heart and the large vessels, the lungs, and the trachea; another

cavity provided only with muscles and membranes in front, in which are disposed under the diaphragm, which separates it from the thorax, the viscera of digestion, the stomach, the intestines, the pancreas, the spleen, and the liver, the internal organs of generation distributed differently in two individuals which form the sexes in the greater number of animals, and also those which secrete the urine.

The limbs or extremities, the one superior or anterior, the other inferior or posterior, formed of bones in their centre, of muscles which cover and move them one upon the other like levers, terminated at their extremity the most remote from the trunk by divisions more or less regular, serve the animals for seizing or repelling bodies, for removing them from, or bringing them nearer to them, and for bringing them into the medium which they inhabit.

6. These three grand parts of the body of animals, the head, the trunk, and the extremities though very different in their uses and apparent structure, are, however, formed of fibres and laminae which constitute textures or kinds of organs which are found throughout. These organs, the first foundations of the animal body, are the bones, the blood, and lymphatic vessels, the glands and the nerves.

The bones are the solid parts which determine the form of the body to which they give extent and solidity. They are connected with each other by solid membranes which are termed *ligaments*; their articular surfaces are covered with

with a white layer, less hard than themselves, compressible and polished, called *cartilage*, and moistened in their articulations with an unctuous liquid called *synovia*.

Over the bones are applied bundles of fibres, united into larger bundles, destined to cause the bones to roll one upon the other, and which are called *muscles*; they have at their extremities white cords, which effect their attachment or insertion into the bones; and are termed *tendons*; they are outwardly surrounded, and held together by hard elastic membranes, with brilliant fibres, which are called *aponeuroses*. The muscles are the organs of motion, and give the external form, the torosity, the roundness, the projections, and the depressions of the surface.

Tubes or strong membranous vessels, proceeding from the cavities of the upper part of the heart, ramified and extended from thence throughout the whole body, conveying the blood which dilates them, and causes them to beat, and these are known by the name of *arteries*. At their extreme terminations they open into other tubes or vessels, which are less dilated, less elastic, and less resisting, which take up the blood, and carry it from the ramifications to the branches, and to the trunks in the cavities of the base in the heart; these are the *veins*. These two orders of canals form together the whole of the blood vessels.

Under



Under the skin and between the muscles, an other order of vessels thin, transparent, and tough, contractes in different places by interior folds. The vessels contain a white and transparent liquid absorbent and lock it the liquid from every part unite and separate innumerable times, and at last pass into the abdomen, behind the intestine and the stomach, whether they carry the liquid which there flows into one, two, or three trunks which then pass into the thorax, and open into a vein situated near to the heart, where the liquid called *lymph* is mixed with the venous blood. These vessels are called absorbents, or lymphatics, they are distinguished into the superficial and the deep, they are very much varied in their structure, and innumerable in their mass. The chyle the product of digestion, is mixed with the lymph which they contain in the abdomen and is poured with it into the venous blood near the heart. The order of absorbent vessels, which immediately draw in the chyle in the intestines, are particularly distinguished by the name of *lacteal vessels*.

In many regions of the body of animals we find masses of blood vessels, contorted in all directions, and having different forms, connected and pressed together by very fine membranes, which are termed *cellular texture*. These vessels thus balled together, interlaced with each other, and forming a kind of net united with one another, very various

various in their volume, are terminated, besides the veins which receive the blood again from them, by canals more or less wide, by reservoirs more or less ample, which pour into different regions, particular fluids. These circumscribed collections of vessels are called *conglomerate* glands. In this class or rank, the brain, the lachrymal glands, which prepare the tears, the parotids, the maxillary, and the sublingual glands which secrete the saliva, the thyroid, placed under the larynx, the use of which is not known, the glands of the mammæ, which prepare the milk, the pancreas, forming the pancreatic juice poured into the first of the intestines, the liver, in which the bile is prepared, which flows together with the preceding fluid, the kidneys in which the urine is secreted, and the testicles, the source of the semen. The absorbent vessels united into smaller intertextures, constitute almost every where, but especially along the large blood-vessels of the neck, of the thorax, and of the extremities, at the axillæ, &c. *conglobate* glands, so called, because they are frequently rounded into a kind of globules.

From the base of the cerebrum, the cerebellum, the medulla oblongata, and the spinal marrow, organs placed in the cranium and the vertebral canal, proceed white cords, which pass out through holes, or fissures, and spread themselves, dividing into branches, into ramifications, and into filaments, more and more minute, into all the other parts with the arteries,  
the

the veins, and the absorbent vessels. They establish a communication with the seat of the sensations and ideas, and serve to form or modify both, as well as to convey the cause of motion according to the impressions made upon the organs of the senses.

All these textures are glued together, though distinct and easily separable, by a series of very fine, and very transparent, flat lamellæ, forming between themselves a multitude of continuous and communicating cells, on which account the whole has been called the *cellular texture*. This texture retains all the parts in their respective places; it is loose and susceptible of distention: it is this which unites the muscular fibres into fasciæ, the different vessels into bundles. It supports such a great quantity of absorbent vessels upon its lamellæ, that modern anatomists believe it to be intirely formed of them. As it is always lucidated with a gluey and mucilaginous liquor, it has also been called mucous texture. We may represent it as a sponge of the same form as the animal body, and into the cavities of which all the organs are as it were stuffed. The fat is deposited in its cells.

7. Besides these first organic elements, or general textures, which extend throughout the whole body of animals, which enter into the formation of the different regions of this body, we must also distinguish; 1. An organ, named sometimes *lungs*, sometimes *bronchiæ*, sometimes

times *trachæa*, and which is destined to establish a communication, an uninterrupted contact between the blood, or other different humours of animals and the air, or the aërated water which they inhale; 2. A system of organs continued between two orifices, frequently placed at the two opposite extremities of the body, which receives, divides, dissolves, digests the aliments, and which represents in general a canal alternately dilated and contracted, provided with instruments and liquids, destined for bruising or dissolving the alimentary substances, to which canal are attached conglomerate glands, which pour into it dissolvent juices, especially the liver and the pancreas; 3. A third system of organs destined to perpetuate the species by generation, partly concealed in the interior of the body, partly situated or projecting outwardly, divided frequently into two sexes, the union of which, urged by instinct, is necessary for the re-production of the individuals. The one of these systems appears to contain the individual ready formed, but void of life; this is the female organ, or the agent of the feminine sex; the other, or the male organ, furnishes an exciting vivifying liquid, which communicates motion and life to the germ; 4. A fourth system which terminates, envelops, and contains all the others under the form of *teguments*, which cover the body, and which is in immediate contact with the water, or the air in which the animals live.

8. Each of the classes of organs, of which I have spoken, constitutes a particular system, having a structure, characters, uses, and nature, different from those of the other systems, actuated by a motion, an appetite, a manner, a sensibility, an activity, an aspect, we might even say a life, which is peculiar to it. Thus we have to distinguish in the anatomical texture of animals, the osseous, or solid *supporting* system, the muscular *irritable* system, the sanguiferous *circulating* system, the lymphatic *absorbent* system, the glandular *secreting* system, the nervous *sentient* system, the cellular *communicating* and *connecting* system, the pulmonary *heating*, *sanguifying* system, the alimentary, or digestive *assimilating* system, the genital *perpetuating* system, and the cutaneous *perspiring* system. Each of these systems is connected with the others, and it is from their agreement, their association, their concord, their simultaneous and proportional action, that the affection of the animal economy results. The more of these systems are united in animals the more perfect they are. Man, who has them all, and in a regular and just proportion, is greatly superior to all the other animals. The diversities of force and energy, varied in the different systems, and their action, constitute the different temperatures in the same species.

9. On the variation of relations of symmetry, of number, of proportion between these systems, are founded the differences which exist between the animals and the classifications which

which have been made amongst them; beginning with man, and descending through degrees of organic degradation, more or less perceptible, down to the insects, the worms, and the zoophytes, in which many of these systems are either wanting or defective, for the more the anatomy of the animals advances, the more we find that the differences between them consist rather in the little harmony between the systems of the organs which constitute them, than in the want or total absence of these systems, as was at first believed. Aristotle first perceived, and this beautiful result has since been confirmed by innumerable anatomical observations, that the differences of these internal systems in the body of animals, were in some degree indicated by great differences in their apparent organs, or in the external parts; that this striking disparity followed and announced, especially in the extremes, the difference of the most important systems, those of the stomach, of the organs of respiration, of the brain, and of the nerves. The skin, naked, or covered with hair, with wool, provided with feathers, covered with scales, with a shell, the extremities more or less dissimilar, long, short, defective, or more or less divided; the fingers, more or less numerous or divided; the spinal column terminated below by the anus, formed of a greater or less number of pieces or vertebræ, prolonged into a tail more or less long, the face vertical or oblique, more or less oblong; the jaws more or less prominent, and

## STRUCTURE OF ANIMALS.

consequently the nostrils, the mouth, and the tongue, more or less elongated; the cranium more or less small, the forehead more or less projecting, with or without osseous appendages in horns: the occipital foramen, placed more or less behind, and in a line more or less approaching to the horizontal or vertical; the jaws, deprived of teeth, or having only few, or only certain classes, or only one of their parts;—these are the most remarkable differences, and most important characters which have been employed for distinguishing and describing the animals from their division into classes, to the separation of genera.

10. According to this varied structure, beginning with the most striking differences, taken from the heart, with two, or with one interior cavity, with red or with white blood, circulating either entirely or only in part through the pulmonary organ, from the stomach single or multiplied, from the brain and the nerves more or less abundant, from the mode of generation, viviparous, or oviparous, and descending successively to the considerations of the body, provided with extremities, four, or only two in number, or destitute of these extremities, of the varied form of these parts, and of their division, of the number, of the situation, of the relation, of the teeth, of the organ of mastication in general, of the skin, naked, with hairs, with prickles, with scales,  
—All the animals, after man, the chief and primitive

primitive type of organized beings, have been distinguished into eight classes, namely the mammalia, the birds, the reptiles, the fishes, the testacea, the insects, the worms, and the zoophytes. The latter, the most degraded in their structure and their functions, fixed to the soil upon which they have been produced, reduced almost to the condition of the vegetables, to which they approach, and with which they have long been confounded, form the last degree in the scale of animals. Without entering upon this division and this classification, into details foreign to my object, I shall content myself with observing, that all the beings comprehended in these ten classes, at the head of which man ought to be placed in a particular and distinct rank; though he has the most striking analogies of structure and of organization with the mammalia, resemble each other in the characters of animality, locomobility, the communications incessantly kept up with the medium which they inhabit, the prompt and sudden re-action of the external objects upon their functions, and especially the union of the digesting, circulating, respiring, moving, sentient, and generating organs. It has been thought, not without some foundation, that the immense tribes of which these six classes of animals consist, form amongst themselves a continued series, an uninterrupted chain of beings, connected by relations more or less close, and descending, by almost insensible gradations, from

1



from man, the model of animals, down to the polypus, the microscopic animalcules, and the sponge. The construction of this chain has much occupied the naturalists, especially Bonnet; and if their investigations have not entirely answered their wishes, they have at least had the advantage of enabling them to compare these beings with more accuracy, and to find between them relations which would not otherwise have been suspected.

## ARTICLE II.

### *Of the Functions exercised by the Organs of Animals.*

1. IN the preceding article I have only spoken of the general structure of animals, of their parts, and of their organs, in order to point out their differences from the vegetables which they otherwise resemble in some general properties. It was a general notion of their anatomy which I wished to give; but this succinct account of their organization, represents as yet only the inanimate machine, and as it presents itself to the scalpel of the anatomist. We should have only a very imperfect idea of these beings, if we did not consider their animated machine, if we did not see their parts re-acting

re-acting the one upon the other, and actuated by the motion which the living force communicates to them. In presenting a sketch of the exercise of this force, in a narrow compass, I have no other intention than to ascertain the real characters with which animals are endowed, instead of proceeding blindfold in the examination of their chemical properties, which are to occupy this section.

2. The animal coming out of an egg, or the womb of its mother, after having received, by the fecundation of its germ, the motion which animates it, and after having experienced in its membranes, either during incubation or in the uterus, the first developments which mark out its traits, and determine its species, and even variety, fulfils a destiny which all mankind observe in the living beings. To be born, to increase in bulk, to acquire its full growth, to remain for some time in this perfect state, to re-produce beings resembling itself, afterwards to decline, and gradually to lose a part of its forms, its powers and its strength, lastly, to perish in consequence even of the efforts which have supported its existence;—this is the circle which Nature has marked out for it, and which comprehends the duration as well as the principal events of its life. She has placed in it a power, which causes it to desire, to take and digest its nourishment, soon to assimilate it with its own substance, to augment the mass of its body, to repair its waste, to carry the super-  
 VOL. IX. C fluous

fluous parts into certain reservoirs, and especially into those which serve for the purposes of generation, and to reject a superabundant or unassimilable portion by canals destined for this use.

3. This principal effect of life supposes a discernment, an appetite, a judgment, which require an immediate communication between the body of the animal and all the beings which surround it; so that it can reject, remove from itself, take, or approach to itself those beings, accordingly as they are beneficial or hurtful to it. In this exercise of its life, all the organs which constitute the animal, all the systems which form the totality of its texture, act simultaneously, with order, with consistency, with regularity, and each fulfils a particular function. The assemblage and description of these functions compose what is named animal physics, or physiology. Ten functions are reckoned to preside over life, which may be distinguished, especially when it is proposed to exhibit their simple result, into four classes.

The first class comprehends the functions which immediately support life, and which were formerly called *vital* functions, because the cessation of any of them produces the instantaneous death of the individual; these are the *central sensibility, respiration and circulation*.

The second class comprehends the functions, which immediately support life, or which pro-  
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long its existence and duration; they have been called *natural* functions; they may be stopped for some time without life being destroyed. Such are *digestion*, *secretion*, *nutrition*, *ossification*.

To the third class belong the functions which render life animated, re-acting in some measure upon the surrounding bodies, which establish direct communications between the living animals and the beings which surround them; these distinguish the animal the most from the vegetable; they constitute its superiority; they are *irritability* and *exterior sensibility*.

Finally, I rank in the sixth class the function which communicates life, which perpetuates the species; this is *generation*. I shall present a sketch of the phenomena of each.

4. By *Central sensibility* I distinguish the function of the cerebrum, of the cerebellum, and especially of the medulla oblongata, which seems to be the primum mobile of all the others, the perfect integrity of which is indispensable to life, at least in the animals in which these important organs are well constituted. It has such an influence upon all the functions, that none of them can exist unless it be in its complete plenitude. Thus in man, in the mammalia and in the birds, a very slight pressure upon these organs renders the individual soporose, paralytic, weakens, alters, or annihilates his external senses; a too strong pressure, a puncture a little deep, an incision, or a wound which penetrates to

the centre of the medulla oblongata, destroys life as suddenly as lightning. Thus an animal is instantaneously killed by thrusting a small knife between the first vertebræ and the occipital. The cause and the mechanism of this eminently vital function are entirely unknown, as is almost every thing that appertains to the living properties of the medullary pulp of the cerebrum, of the cerebellum, of the medulla oblongata.

5. *Respiration* is not a function immediately vital in all classes of animals; it has this character only with those in which the blood is obliged to pass through the respiratory organ previous to its being sent into all the regions of the body, as in man, in the mammalia, and in the birds. With the others in which the blood is not obliged to follow the course that has been indicated, at every moment of life, respiration may be retarded, interrupted, partial, momentaneous, periodical, or in general irregular. Its purpose is to bring the blood, either wholly or in part, at every instant, or at certain intervals into contact with the air and aerated water. The lungs in man, in the mammalia, and in the birds, the gills in fishes, the tracheæ in the insects and worms, are the organs of this function. It consists in two alternate motions, the one by which the air is received, or *inspiration*, the other by which the air is evacuated, or *expiration*; an effect takes place between the air and the blood, which modifies the

the latter and renders it adapted for life, and the nature of which chemistry, as shall be seen, teaches us to determine. It contributes to support the circulation, which, in a great number of animals would not take place without it. The diaphragm, the ribs, the muscles attached to them, exercise its motions in the most perfect animals, in the birds it is still more energetic on account of the organs accessory to the lungs, which, with them, extend into their bones and their feathers. It extracts the air from the water in fishes, which cannot live in water that has been boiled.

6. *Circulation* is the motion of the blood from the heart into the arteries, and from these into the veins, which carry it back again into the heart. It takes place in animals without interruption. The heart is endowed with a great force for expelling this liquid, which, as it dilates the arteries, causes them to pulsate: this first order of vessels possesses a power of contraction which propels the blood into the last ramifications; the veins do not possess the same power; the blood is propelled in them by the side which presses it, by the valves which prevent its retrograde motion, by the vacuum which its progress produces, by the pressure of the adjacent parts and especially of the muscles. This function is two-fold in man, in the mammalia and in the birds; the one is pulmonary, and carries the blood by a short passage from the right to the left cavities of the heart; the other, which is

is general, carries it from the latter cavities into the whole body, and brings it back to the right side: these two circulations form together a route, which is pretty well represented by the type or figure 8. In the animals placed below the birds, the heart has not the same number of cavities, and the blood does not take exactly the same course; respiration is not necessary to the integrity and the continuity of its circular motion; the cavities, the canals through which it passes, the course which it takes, vary, and descend, in some measure through a scale of degradation down to the lowest classes of animals. The three inferior classes, the testacea, the insects, and the worms, have white cold blood, a heart imperfectly organized, or a dorsal vessel which supplies its place, an irregular and very feeble circulation. The zoophytes, the last class, have neither heart nor circulation.

7. Digestion consists in the introduction of aliments into a canal or sac in which their nature is changed, they become softened, dissolve and separate into two substances: the one, the chyle, which passes into the vessels in order to renovate the blood, and serve for nutrition; the other which passes out of the body in the form of excrement. This function is very much varied, both with respect to its organs and to its results, in the different classes of animals, and frequently even in different genera of the same class. We may, however, distin-

distinguish in it four periods : the first, the preparatory, comprehends the bruising, mastication and deglutition ; the alimentary bolus is formed and conducted into the stomach in this first period ; the second, which comprehends the digestion in the stomach, or the change of the alimentary matter into chyle, or homogeneous pulp ; the third, which belongs to a second change produced in the intestine, and which separates the chylous matter from the excremental ; finally, the fourth, which comprehends the absorption of the chyle that has been formed, by the lacteal vessels, and the expulsion of the excrement.

These four periods are very distinct in man, in the mammalia, the birds, the reptiles, the fishes, and the insects. They present in them a multitude of modifications, determined by the form of the organs of manducation, deprived of teeth or provided with teeth of very different kinds, destined for bruising, tearing, cutting ; by that of the stomach, simple or quadruple, or divided into craws, of the gastric juice more or less dissolvent or weak ; by the nature and the quantity of the bile and of the pancreatic juice, which form the second digestion, and effect the separation of the digested aliments into a chylous part and an excrementitious portion ; by the very various length of the intestinal tube, which in general is short in the carnivorous, and very long and contorted in the frugivorous and granivorous animals ;  
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by the form, the size, the texture, the secretory force of the pancreas, of the liver, &c.

This function has not the same distinct periods in some insects, the testacea, the worms, and especially the zoophytes. With the latter, it is merely a simple passage of the aliment into a sac or a tube, in which a suction, equal in all points, is performed.

8. *Secretion* is so termed because it is supposed to separate different humours from the blood. It is performed by the glands; it is in this manner that the saliva is separated in the salivary glands, the bile in the liver, the urine in the kidneys, the pancreatic juice in the pancreas, the synovia in the articular glands, the sperm in the testicles, &c. &c. It is, however, not a mere separation, which would presuppose that each of these liquids was contained ready formed in the blood; but a real particular change of the latter in each gland, as I shall show at the close of this section. There is no function in animals which is more general, more extended and more varied than this. It presents a multitude of particularities in the classes, the genera, and even the species of these organized beings, according to the particular wants of the species. It constantly consists in a preparation of the blood before it arrives at the secreting organ, in its change and in the separation of the matter secreted in the interior of this organ itself, and in the exit or ejection of this humour, frequently effected by an excre-

tory duct. This latter circumstance is owing to the vital action, a kind of irritable motion of the excretory duct, which experiences an orgasm, a very well marked erection, at the contact or at the mere sight of the stimulant appropriate to it, as the saliva which runs and gushes out of the salivary ducts, at the sight or even at the mere idea of the aliment that excites the appetite, &c.

9. *Nutrition* is the end of digestion and assimilation. The alimentary matter converted into chyle, poured in this form into the blood, assimilated by its mixture with this liquid, vivified by respiration and circulation, is carried by the latter into the different organs; it deposits in each the substance proper for exalting and supplying the loss which it has sustained. It is changed especially into lymph, which being transported into every part and into all the cavities, all the cells of the cellular texture, furnishes there that mucous, plastic jelly, disposed for forming the transparent and gelatinous laminae of which most of the animal substances are formed. On this account the lymph has been appointed as its nutritious base, and the mucous texture as its seat or organ. However, the idea of nutrition must be still more generalized; and each muscular, pulpy, membranous, parenchymatous, cellular organ, considered as possessing the property of appropriating to itself, in the blood and the lymph which passes through and penetrates it, the matter destined for

for its own repair. In fact, the excess of this nutriment is taken up again, with the part of the organ in some measure worn and melted, by the absorbent vessels, which pouring it into the tide of the circulation, renew or transport it outwards by transpiration. The nutrition is much more active in the first periods of the life of the animal, when its organs, which are dilatable and extensible to a determined degree, grow till they have attained this term. On this account the digestive powers are at that period of life more energetic, the appetite keener, and the quantity of aliment required more considerable. It is modified in the different classes of animals according to their nature, and very simple in the last.

10. *Osification* deserves to be considered as a particular function, on account of the important part which it acts in the phenomena of life ; the formation of the bones in the first periods of the life of animals has a great influence upon their existence and their strength. Though this is really nothing more than a secretion of osseous and solidifiable matter, in the gelatinous organ, which forms the base of the bones, this secretion is so general, it holds such an important place in the animal economy, that it ought to be considered and studied in particular. The bones, after having been membranous in the first formation of animals, becomes solidified at their centre and in divergent rays in the flat bones ; in three points, at their middle  
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and their two extremities, in the long bones ; in the latter the bones remain for some time separated from the body of the bone under the name of epiphyses ; they do not glue themselves together till about a sixth of the period of life has elapsed. Towards the period of old age, the bones become more brittle, because the proportion of the solid salt increases in them. These organs, the totality of which constitutes the skeleton, do more than give form, extent, and support to the different parts of the body of animals. They are also levers movable upon each other, which cause these parts to assume various situations with respect to one another, which favour locomotion, which serve for the execution of all the motions and the action depending thereon. We might therefore refer ossification in this point of view to the class of functions, which establish a communication between the animals, and the bodies which surround them.

11. *Irritability* is one of the animal functions which present the most wonderful circumstances and phenomena difficult to be comprehended. This name is given to the living power by which the muscles or the organs, which form the flesh of animals, contract themselves, change their dimensions, approach and move the bones one upon the other. Their contraction or the diminution of their length, and their dilatation in breadth and depth, their change of dimension in general, are effected by the aid of a stimulus, which is directed by the will,

will, and which seems to proceed from the focus of the central sensibility; they are executed by a motion, the cause of which is not known. We know that the concurrence of the vessels and nerves is necessary, in order that it may take place in the animals in which the last-mentioned organs are found. It is also known that by establishing between the nerves and the muscles a communication with the aid of two different metals in contact with each other, we cause this motion to be produced at will, and this important phenomenon bears the name of Galvanism, because it was discovered by Galvani, an Italian physician. Finally, all the experiments have shown that this function, which exists in all animals, is very energetic even in those whose flesh is white, and down to the Zoophytes, in which neither brain nor nerves have been discovered. A puncture, a bright light, or a caustic, excite contraction when they are placed in contact with the muscles. It is to this grand property of the fleshy fibres that all the motions of animals are to be attributed, from that of the heart which acts incessantly and without their participation, to that of the smallest of their muscles, which they cause to act at will.

12. The exterior sensibility comprehends all the senses placed in different regions of the bodies of animals, but more particularly in that of the face, where they are almost all united in a line very near to the brain. The study of this function, which presents the organs and the sensations

tions of the sight, the smell, the taste, hearing, and touch, is of all the parts of physiology, that which presents to the observer the greatest number of remarkable facts, and the most varieties in the structure and relative extent of each of the sensations in the different classes of animals. These sensations are in general perceived by the nervous extremities spread out in a transparent jelly at the bottom of the eye, into short and pulpy filaments in the internal ear, into flat and long filaments in the nostrils, into projecting papillæ upon the tongue, and into soft and extremely numerous tubercles under the skin. The impression made by light, by sounds, by smells, tastes, surfaces, is transmitted to the focus of central sensibility by the nerves which propagate it to this focus, which is called the *sensorium commune*. The sentiment of pleasure or pain, which follows this transmission, and the comparison of these different, successive, multiplied, modified sensations, gives rise to the ideas and produces all the voluntary motions destined for the support of the life of the animal, by furnishing it with the means of removing or avoiding that which is pernicious, and approaching or seizing that which is beneficial to it. None of the animals have, in the number and the relations of their senses, and consequently in that of their sensations, the same harmony and proportion which constitute the perfectionable character of the human species.

13. Generation, the most incomprehensible and the most hidden of the functions of the body of animals, by perpetuating these beings, carries into these individuals which all proceed from the same stock, a resemblance of form, of structure, and of properties which rigorously determine the species. In this function we scarcely know the organs by which it is accomplished, and the result of their mutual action; even the mode of their exercise, the cause of their effects, the mechanism of fecundation, are covered with a veil the most obscure and impenetrable to man. Anatomy and physiology have nevertheless made numerous and important discoveries, and established some general truths concerning this mystery. They have shown that all the animals which exist have formed an integrant part of animals similar to those from which they have been separated; that this separation, this detachment of animals from their parents is effected in several different ways, that in the animals the most simple and the least complicated in their structure, there are formed, as in the vegetables, buds filled with small animals similar to those from which they proceed, and which detach themselves at a certain period of growth, or that a fragment of their substance separated from a first adult individual, forms an animal intirely similar to this, like the slips in plants; that in others, and those are the most numerous, the concurrence of two organs, the one under the name of ovarium, containing

containing the animal ready formed, but not animated and living, which is the feminine organ; the other containing a liquid capable of exciting by the slightest contact the motion of life in this embryo, which is the male organ; that those two organs necessary for the fecundation and re-production, are sometimes united in one and the same individual in such a manner as to render it either sufficient for itself, or to admit of a double production in each individual, which then is androgynous; that most commonly the two organs are separated in two individuals of the same species, which is termed *sex*; and that they require, for the purpose of fecundation, their union or copulation; that this union of the two sexes is solicited by an imperious want, by an appetite more or less violent, which has its period in every year; that this appetite does not show itself thus except with the power of satisfying it, and of engendering when the growth of the animal is completed, or when the animal is perfect; that it appears to arise from an excess of nourishment, of which the organs, which no longer grow, are no longer in want; that on this account it becomes more powerful, much more frequent, and has no longer any regular period when the animals are furnished with a very abundant and very succulent nutriment; that when the act of fecundation has been performed, the embryo animated by the spermatic liquor grows, either in the womb of the female, or  
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out of it; that after a certain determined time, it comes out of it, inclosed in a shell or membrane in the form of an egg, and that it now requires only a certain temperature in order to be hatched, as in the oviparous animals; that in the same manner, in the viviparous animals, the embryo, having become a fetus by fecundation, is developed in a given time, lives in the womb of its mother, immersed in a liquid, and inclosed in different coverings, and that it leaves the womb when it has acquired a certain growth; that when it has once left the egg or the womb, the young animal, in the first classes of animals, still retains for some time a particular structure in the organs of respiration and circulation; but gradually loses this difference, in proportion as it respire and nourishes itself after the manner of its parents; and that finally at the end of its growth, its being is completed, and perfected to the period when the necessity of producing its like, of communicating the excess of life which it enjoys in all its plenitude, is felt with the last development of its organs.

## ARTICLE III.

*Of the Succession and of the History of the Discoveries in Animal Chemistry.*

1. HOWEVER rapid the sketch of the structure, and of the functions of animals, comprehended in the preceding articles, may be, yet it is sufficient to show the difference which exists between them and the vegetables; and though intended only to serve as an introduction to the examination of their chemical properties, it is also sufficient to show, that, notwithstanding the difference which subsists between these two classes of beings, there nevertheless exist between them a greater number of relations and analogies than are remarked between the plants and the minerals. In the investigation of the real differences which separate these two orders of organized beings, the labours of chemists have not been fewer than those of the anatomists, and if the success of their experiments has been inferior to that of the description and knowledge of their organs, modern chemistry has supplied this deficiency, which depended only upon the imperfection and the inaccuracy of the means and instruments which she has possessed only for some years past. It will

be an inquiry, no less curious than useful, how this science has arrived at the point of perfection which it has now attained in this kind of analysis, through what stages it has passed, and what may still be expected from it, from the light which it has already thrown upon animal physics.

2. The ancient chemists, occupied in the search of imaginary properties, in most of the natural productions, either for the chimera of the opus magnum, or for the treatment of diseases, have given nothing but erroneous notions concerning the animal matter. Their decomposition by fire was the only method which they followed, and the source of these errors. Nothing useful is to be found before the middle of the seventeenth century. Few chemists even occupied themselves with them, either on account of the disagreeableness and fetidity of this analysis, or on account of its difficulty, or lastly on account of the sum of collective knowledge which it required, and the few chemists whom it interested, in times when all were zealously engaged in the examination of the minerals. I divide the history of animal chemistry into eight epochas, each marked by some great discovery which characterizes it, more than by the time in which each of them can be fixed.

3. The first epocha, which dates from the middle of the seventeenth to the beginning of the eighteenth century, is remarkable by a kind of  
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of invasion which chemistry made into medicine, by introducing into it its ridiculous theory of the acids and alkalis. It succeeded the chimeras of the panaceas, the elixirs of life, and potable gold, which the alchemy of the adepts had before introduced into the practice of the art, which at least was corrected by the beneficial acquisition of the mercurial and antimonial remedies, of opium, &c. Tachenius, Willis, Vieussens, Sylvius, were the most celebrated propagators of chemical medicine, founded upon the acids and alkalis. The functions of animals, according to them, were performed by effervescences and fermentations; the acid and the alkaline humours mixed and contended together; maladies arose from the excess of the one or the other, and the therapeutic art combated them with remedies of a contrary nature. The art of healing was for some time infected with this error, which was destroyed only by the rise of experimental philosophy.

4. I attach the second epocha to the efforts which some great physicians, equally illustrious by their knowledge of chemistry, were obliged to make in order to destroy the absurd and pernicious ascendancy which the theory of the acids and alkalis had assumed in the art of healing. After the first successes of experimental philosophy; after the great revolution effected in the sciences by a Bacon, a Newton, and a Boyle, Stahl and Boerhaave occupied

themselves with liberating medicine from the errors which hypothetical chemistry had introduced into it. They were obliged even to rate its use in the art of healing almost as an absolute nullity, in order to combat the predominant theory; they appeared almost to despise the important labours and first outlines of Mayow, Boyle, and Hales, who had borrowed from chemistry new means for advancing animal philosophy, in order to repel the noxious invasions which it had made in the healing art. Their great influence upon those who taught, studied, and practised medicine, had all the success which they aimed at; and it was believed that chemistry could have no other use in medicine than that of furnishing new remedies, or improved modes of preparing them. This second epocha dates from the commencement of the eighteenth century to nearly a third of its duration. The theory of the acids and alkalis was overturned and soon forgotten.

5. The third epocha in the history of animal chemistry, dates from the moment when the operation of the phosphorus of urine, found accidentally in 1677 by Brandt, discovered some years afterwards by Kunckel, prepared for a long time exclusively in the laboratory of Godfrey Hanckwitz, at London, for all Europe, was taught at Paris by a foreigner, and described in 1737 by Hellot, in the Memoirs of the Academy of Sciences. This process, though tedious, difficult, expensive, and disgusting, was

was the signal of the revival of animal chemistry, which then was almost intirely neglected. Chemists began zealously to labour upon urine. Margraff found that the *microcosmic* or *fusible* salt, the phosphate of ammonia, was the source of its phosphorus; that it did not proceed from marine salt, as Stahl had asserted; he gave an excellent process for preparing it, by means of the muriate of lead, added to the extract of urine, and which serving to decompose, without his knowing it, the phosphate of soda, greatly augmented the quantity of phosphorus obtained: he even found, if not the real difference of these two salts, yet at least that there were two different ones in urine. Pott, in 1740 Haupt and Scheffer, in 1753, also described the properties of the fusible salts or phosphates; Haupt even distinguished the phosphate of soda by the name of *pearled salt*. - Rouelle the elder, who commenced his lectures at Paris about this period, not only succeeded in making phosphorus for several successive years, but began to multiply his researches and his products upon the animal matters. In glancing over the processes of his course of lectures, published in 1762, we find that he had caused this department of knowledge to make much greater progress, than it presents in the works of his predecessors, especially in those of Boerhaave.

6. The fourth epocha in this department of chemistry, still so new and so little cultivated, is pretty accurately fixed by the labours of  
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Rouelle the younger. Educated for a long time in the school of his brother, possessed of the notions of this learned chemist, accustomed especially by long practical studies, to make more exact and more precise analyses than had been made before, distinguished amongst all the chemists of his time, by his great and valuable skill in distinguishing bodies, and separating them ably from each other; he particularly occupied himself with animal chemistry, for which he seemed to have acquired a peculiar predilection. He published successively in the Journal of Medicine of Paris, from the year 1773 to 1777, numerous and new inquiries concerning the salts of the blood, the water of hydroptic patients, the human urine, the urine of the cow and the horse, compared with each other, concerning the sugar of milk, concerning the blood, concerning the fusible salts, and concerning the urine of the camel. He confirmed the discovery, made in Italy by Menghini, of the presence of iron in the blood. All his analyses, described with ability and simplicity, given without forced applications to medicine, presented new truths, which diffused a light over several points of animal philosophy. The physicians availed themselves of them, as well as of those of Citizen Cadet upon the bile, which he proved to be a soap, in the year 1766. Bucquet advanced a little further in the art of analysing the blood. Poulletier de la Salle announced some new facts concerning a concrete  
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and crystalline substance contained in biliary calculi. The wise and reserved progress of all these labours, recalled the mind to the advantageous use of animal chemistry, and the aid which it offered to the art of healing. Successful researches were then made into the characteristic differences between the chemical properties of animal and vegetable substances. Several animal acids were discovered; and the presence of the phosphoric acid in several of the animal humours was ascertained. In a word, chemists became inspired with new courage, and this kind of analyses assumed a lustre which it had never exhibited before.

7. The fifth epocha which I distinguish, is remarkable for three extremely striking discoveries relative to the animal analyses, made in Sweden during the same time that belongs to the preceding, but known somewhat later in France. In 1772, Scheele, a Swedish apothecary, and Gahn, doctor of medicine in the same country, discovered the phosphoric acid in the bones of animals, the solid matter of which they ascertained to be phosphate of lime, and described means for separating from them these substances, which till then they had not even been suspected to contain. Rouelle the younger, Nicolas de Nancy, Berniard, Poulletier de la Salle, and Macquer, confirmed this discovery, and added several important facts, with regard to the comparative nature of the bones of different animals, and the process of their analysis.

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## 40 HISTORY OF ANIMAL CHEMISTRY.

This salt has been found amongst the fossils, and afterwards the chrysolite was discovered to be composed of it. Scheele announced, in 1776, that the same salt, the base of the bones, existed in the human urine with an excess of phosphoric acid which rendered it soluble. In the same year, and in the same Memoir, the Swedish chemist discovered a particular acid in the calculi of the human bladder. It was then, that by comparing these three capital discoveries with several facts of physiology and pathology, it became generally acknowledged that chemistry, treated in this manner, might be applied with great utility to the art of healing, and that so far from there being any reason to apprehend the errors which had already endangered its fate, on the contrary, its important applications could no longer be dispensed with.

8. At the same time nearly, and confounding itself with the preceding, though deserving to be distinguished by its object and its views, is placed a sixth epocha, not less important than any of those that have been indicated. It is constituted by the first data which the pneumatic doctrine, still in its infancy, afforded to the chemistry of animal matters. Lavoisier, while operating in the year 1774, upon the analysis of the air, ascertained with precision the ancient, but vague comparison which had been made between the respiration of animals and combustion, and found that it altered the  
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air after the manner of charcoal. Condorcet then gave the name of vital air to the respirable part of the air. Crawford found in respiration, and in the air, which is subservient to it, the source of the animal heat. Carminati discovered that the mephitic, in rendering animals insensible, destroyed the irritability of the heart and of the muscles. Lavoisier was successively led to study, with Citizen Seguin whom he took as the associate of his researches, the phenomena and the influence of transpiration, and to ascertain that a great analogy subsisted between this function and respiration. Citizen Spallanzani at the same time made a kind of living analysis of the gastric juice, and confirmed its dissolvent quality, which had been already proved in 1743 and 1744 by the ingenious Reaumur; he also discovered in it a strong antiseptic power. This new career, which, it is evident, deserves to form an epocha in the history of animal chemistry, has not since been interrupted. It has diffused the clearest light over the physical nature of animals, and proved that phenomena, which are truly chemical and appreciable, take place in the exercise of their functions. It is in some measure a living chemistry, which Mayow had a glimpse more than a century ago, which was pursued in some points by Hales at the beginning of the eighteenth, and resumed in our time by its relations equally essential and immediate with the principal phenomena

nomena of the pneumatic doctrine which stand in so natural a connection with it.

9. The seventh epocha, which is still more important than the preceding, on account of the greater number of objects discovered, or at least illustrated, which it includes, and the generality which it embraces, relates intirely to the researches of Citizen Berthollet. This illustrious chemist, after having embraced, in the year 1784, upon the discovery of the composition of water, for which we are indebted to Lavoisier and Citizen Monge, the pneumatic theory which appeared to him to be confirmed by this discovery, advanced animal chemistry a new step forwards, by fixing the nature of ammonia which Scheele had only suspected, and by discovering in animal substances a large quantity of azote. Ammonia being decisively ascertained to be a compound of five parts of azote and one of hidrogen. Citizen Berthollet shewed how it was formed so often by the action of fire, by putrefaction, &c. in animal substances so highly charged with azote. He proved, moreover, that the presence of the phosphates, and the abundance of hidrogen amongst their principles, contributed greatly to this difference. There is especially in this new set of data, which we owe to the French chemist of whom I speak, and in the epocha which I consider them to constitute, a character by which it sensibly differs from the preceding epochas; namely, that this seventh epocha presents

sents a more general and more complete totality and result than the others; that it refers not merely to a single substance or to several animal substances in particular, but to all these substances at once; that this investigation having afforded a knowledge of the whole mass of animal compounds, those which have followed it have acquired a certainty, precision, and stability, which they could not have had without it, as will be proved by the exposition of the eighth and last epocha of this historical sketch.

10. This eighth and last epocha comprehends the combination of the labours already indicated in the seventh, and the application, since become more immediate and more easy, of the analyses to the physical Philosophy of animals, with the uninterrupted success of these applications, and the real existence of a new career, proper for explaining the most obscure phenomena of this philosophy, provided it be constantly pursued. It is especially from 1777 and 1788 that this epocha ought to be dated, and it extends to the present moment. We find in it new and valuable analyses of milk and blood by Citizens Deyeux and Parmentier, of the synovia and of the humour of vesicatories by Citizen Margueron, of the liver of cartilaginous fishes by Citizen Vauquelin, of the human sperm by the same chemist, of the saliva by Mr. Siebold; the discovery of a new animal acid, formed by distillation, and called zoonic acid by Citizen Berthollet. I, in particular, have

have not ceased, in this last epocha, to continue, availing myself of all the new means afforded by the pneumatic chemistry, the series of researches which I long ago commenced upon almost all the animal substances, for the most part with the assistance of my friend and pupil Citizen Vauquelin; I have published a great number conjointly with him; and some of them are peculiar to myself. A rapid enumeration will be sufficient to afford an idea of them; the conversion of bodies buried in the earth into a fatty matter, combined at first with ammonia, the resemblance of this fatty matter with spermaceti, and with the lamellated and concrete part of biliary calculi; its generality or its abundance in most animal substances, which has induced me to consider it as one of their most constant products, and to designate it by the name of *adipocire*; the proportion of azotic gas disengaged by the nitric acid from different animal substances compared; the existence of this gas in the air-bladders of carps; the presence of gelatin and sometimes of bile in the blood; the concrescibility of the albumen, owing to the fixation of oxygen, and the varieties of this humour, dependant upon the proportion of this principle; the presence of the phosphates, and especially of that of lime in many of the animal liquids, in which it was not known before, particularly in milk; the absence of phosphoric acid in the urine of infants; the calcarous benzoate which supplies the place of the

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the phosphate of lime in that of the herbivorous mammalia; the analysis of the tears and of the nasal mucus; their catarrhal thickening by the oxygenated muriatic acid; the analysis of the intestinal calculi of horses, since confirmed by Citizen Bartholdi of Colmar; that of the renal and vesical calculi formed by the carbonate of lime, which admits of the lightest and weakest acids as lithontriptics; the horns, the hair, the transpiration of these animals, containing and evacuating the phosphate of lime; the production of the Prussic acid by the distillation of the human calculi; the same, formed in the treatment of all these animal matters by hot nitric acid; the instantaneous formation of ammonia in all these matters treated by the caustic alkalis; that of water, when they are treated in the cold by the concentrated sulphuric acid; the partial decomposition of the phosphate of lime by the acids, the formation of the acidulous phosphate of lime and not the simple and pure disengagement of the phosphoric acid: so that by the processes hitherto given, we do not by far obtain the whole of the phosphorus contained in bones; a new analysis of the calculi of the human bladder, which has proved the presence of four substances which were not known to exist in them, and which singularly vary their nature; namely, of the ammoniaco-magnesian phosphate, of the combination of uric acid with ammonia, of the oxalate of lime in the mural calculi, and of silex, the most

most rare indeed of these calculous matters; the ascertaining the real solvents of calculi, and their necessary diversity according to the nature of these concretions; a more profound examination of the human urine, and the discovery of the ammoniaco-magnesian phosphate which is formed in it, as also of a particular matter which gives to this liquid its characteristic properties, and which I call urée; the medicinal action of the oxygenated substances, so much applied to since by several English Physicians; the preparation of fat furcharged with this principle, employed at present with so great success by one of my pupils, Citizen Alyon, who has particularly followed up my first views relative to this subject, and has carried them very far: such are the principal researches in which I have been engaged since the epocha when my friend Berthollet, by his important discoveries, fixed the progress of animal chemistry, which till then had been uncertain and wavering.

11. Though this is not the place to show how all these labours and discoveries have influenced the progress of Animal Philosophy and the art of healing, it will be easily conceived, from the simple and precise sketch which I have just presented, how many useful applications must have been derived from their results, and what great advantages they promise to medicine. It is evident that this is the only manner of determining the differences which subsist between

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tween the different animal substances, of explaining their formation, and the alterations of which they are susceptible; of furnishing to Physiology what the most minute anatomy and the most exact and multiplied observation of what passes in living animals could never afford, as these two means are so soon exhausted. Moreover, these first data, already so important and so useful, are the fruits of the labours of only a few men. Unfortunately, the number of labourers is very inconsiderable in proportion to the immense researches which this part of chemistry requires, and the multitude of questions to be solved which it presents. Scarce a twentieth part of the chemists whom Europe possesses direct their views to this object. What will it be when, having become more universally diffused, more familiar, and preceded by all the interest which they ought to inspire, these grand researches shall be multiplied; when hospitals appropriated to this useful investigation shall have assumed the activity which their importance claims; when the physicians shall no longer neglect their opportunities of analysing the morbid matters, &c.

12. It is then that all the hitherto incoherent parts of the new discoveries relative to animal chemistry will be approximated and linked together, by relations which yet can only be partly foreseen and suspected; it is then that a monument will be raised for which we are as yet only collecting the first materials. Some



persons, indeed have already been too precipitate in making applications of the modern chemistry to the art of healing; they have been too hasty in forming from them a medical system, either of the nature of diseases, or of the employment of remedies. Whatever zeal these first attempts may indicate in their authors, they are, however, to be censured for an exaggeration equally detrimental to both of these sciences, which they have attempted to connect together by premature approximations. They are not, as formerly, chemists properly so called, who have ventured upon this enterprize; these theorists are not those particularly to whom we are indebted for the most connected investigations, the most numerous experiments, the recent discoveries upon the animal matters, who have attempted to form a chemical system in medicine. Rouelle the younger never proposed any thing of this kind; Scheele has only given an account of the particular facts which he discovered; Citizen Berthollet to whom we owe so many and such ingenious labours in this new province of chemistry, has allowed himself only to make some particular applications of them; and if I may be permitted still to quote myself here, after the researches relative to this department of the science, in which I have been incessantly engaged for nearly twenty years past, I have never even attempted to establish a general theory. I am thoroughly convinced that the efforts of chemistry will hereafter change  
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the aspect of medicine, that they will produce a happy revolution in this as well as in all the other departments of physics: but this period has not yet arrived, and too many deficiencies still remain for these changes to be admitted. I shall carefully collect, at the end of this section, such important applications as the actual state of chemistry permits to be made to animal philosophy, to which I shall at the same time subjoin several new prospects, which naturally present themselves: but so far from forming a complete system, it will be seen that they only prove the necessity of continuing our investigations and not relinquishing a series of inquiries which will hereafter conduct us to the desired end.

#### ARTICLE IV.

##### *Of the General Results of the Modern Experiments upon the Animal Compounds.*

1. THE labours of the modern chemists upon animal chemistry have not been confined to adding a more or less numerous series of new facts or of insulated discoveries to those which had been made before them; they have more especially conducted philosophers to general results respecting the nature of the animal compounds.

It is even in this circumstance that the real difference between the epocha of the pneumatic chemistry and those which had preceded it consists. Till then the ancient chemical facts presented neither a general coincidence, nor data that could be applied to all animal matters; they formed truths unconnected with one another; they admitted of none of these approximations which really constitute the science, and without which it does not exist.

2. One of the principal objects of these labours has been to examine with attention the analogy announced after Boerhaave between the animal and the vegetable compounds. They have been found to resemble each other in their complication; they have been considered as substances which, having at first been vegetable, have acquired in the bodies of animals, and by their vital powers, a more complicated composition. Since that time we have been able to consider the organs of animals as chemical instruments, destined for uniting a greater number of principles together than the vegetable instruments; provided, however, that they should act upon compounds at least ternary, already previously formed in the organic texture of the plants; for observations easily show that no mineral substance can be changed immediately into animal matter in the bodies of animals.

3. In order to establish this comparison, which ought, however, to conduct us to the deter-

determination of their differences ; after having represented the animals as formed, like the vegetables, of immediate principles, in the enumeration of which an extractive matter has been found in the flesh, &c. a gelatinous mucilage in the membranes and the bones, answering to the vegetable gum, a sugar of milk answering to the sugar of plants, fats representing their fixed oils, resins, particular acids, and the albumen resembling the gluten of flour ; it was very natural, immediately after the labours of Rouelle, that we proceeded to consider the animal matters as real immediate materials of vegetables, modified only in some of their properties.

4. But without entirely rejecting every part of these analogies, it was soon found that they ought not to be admitted in too strict a sense ; that they exhibit perhaps more differences than resemblances between these two classes of bodies when compared with each other ; that none of these immediate materials could be rigorously judged to be of the same nature ; that the more attentively they were examined, the more distinct characters they were found to possess ; that thus the immediate materials of vegetables which pass into the bodies of animals speedily acquire in them, and by the slightest exertions of the vital power, properties very different from those which they originally possessed. Besides which, the different substances entering into the formation of the body of ani-

mals were subject, as immediate materials, to a more easy separation, because they are more insulated from each other and more disposed to separation, it was also found, that such of these materials as appeared to be the most similar to some one of those of the vegetable, nevertheless differed from it much more in its intimate nature, and consequently in the phenomena which is presented in chemical experiments than had at first been imagined.

5. The changeableness of the animal matters already verified long ago, announced that their more complicated composition was the principal cause of it; we began clearly to conceive why they were less permanent than the vegetable substances, why they were decomposed more easily and more speedily, why their changes were more rapid, and why they never remained in the same state. The number of their primitive principles being greater, had it been augmented only by a single one more than the three which have been well ascertained in the vegetable compounds, namely carbon, hydrogen, and oxygen, —the single addition of azote to these three first constituent elements of the vegetable alimentary matter,—an addition produced by the phenomena and the powers of life, is sufficient to enable modern chemists to explain their changeableness, by calculating the multiplicity of attractions to which this number of the principles must give rise.

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6. This last notion, acquired chiefly from the discovery of Citizen Berthollet, conducted me to another not less general or less important, relative to the animal matter; namely, that when deprived of the azote with which its composition is complicated, especially by the action of diluted nitric acid, this matter seems to experience a retrogradation, and to return to the state of vegetable matter, such as it had been before it had undergone animalization. It is thus that I easily account for the abundant conversion of the animal compound into an acid similar to that which is also produced by the chemical art in the vegetable matters; an acid which it affords even in greater abundance than the materials of plants do, as Citizen Berthollet had announced some years after the discovery of the preparation of the acid of sugar, or the oxalic acid by Bergman.

7. The complication in the composition of animal substances, which is the common source of their differences, and at the same time of analogies with vegetable substances, does not consist merely in the addition of azote, but also in that of sulphur and of phosphorus; these three combustible bodies, combined with carbon and hydrogen, are the common source of the fetid gases diffused by animal compounds during their decomposition, by whatever agent it may be effected. The tendency which two of them have to assume the form of gas, and that which the three others have to dissolve

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dissolve together or separately and in very different proportions in the two former, are the causes of this fetor, which has always been acknowledged as one of the most marked characters of the animal substances.

8. We must also reckon amongst the important results afforded by modern chemistry, relative to the composition of the animal substances, and their general differences, the presence of the phosphates so accurately established by Scheele, by Citizen Berthollet, and by my own investigations concerning those substances. It will soon be seen, not only that these salts form sometimes nearly the whole texture of several organs, that they give a more or less marked character to some of the liquids of animals, but also, that they act an important part in the chemical phenomena which both present to the observer; and that they give rise to some of the principal properties which are discovered in them by analysis. In this abundance of the phosphates, consists one of the most striking differences presented to the chemist by the animal compound compared with the vegetable.

9. Lastly, we ought to refer to the totality of the modern discoveries, and to the new analysis of animal matters,—we ought to rank amongst their most valuable results, the knowledge which they have afforded concerning the proportion, or the relation of quantity, between the constituent principles of those matters. Without this knowledge all the rest would be barren,

barren, it is this which fecundates it by rendering it complete. It has been found that animal matters contain more hydrogen and less carbon than the vegetable; more sulphur and phosphorus, more phosphates with different bases than the vegetable compounds; and that the conversion of the latter into the state of animal compounds does not consist merely in the addition of some principles and the complication of their composition consequent upon this addition, but also in the change of the proportion of those principles.

10. Thus the general result of all the various labours upon the animal analysis, that which includes all the other particular results, which gives rise to them, and which is their common source, shows that animal matters are compounds, at least quaternary, formed by the union of hydrogen, of carbon, of azote, and oxygen, with which are frequently associated, in very variable proportions, sulphur, phosphorus, lime, magnesia, and soda. These compounds, less carbonated but more hydrogenated than the vegetable substances, are brought to the state of oxides by the oxygen they contain. The proportion of hydrogen in them being more considerable, the azote being very abundant, the phosphorus and the sulphur frequently uniting in them their particular attractions, there result from them, matters more or less combustible, easy to be decomposed, very alterable, very fetid in most of their alterations,  
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very much inclined to assume the oily character, and to furnish ammonia. These are the truths well established by the new discoveries; and all that will follow this general exposition in the present section will be only a development or application of these doctrines.

## SECOND ORDER OF FACTS.

### *Of the Chemical Properties or Characters of Animal Substances in General.*

#### ARTICLE I,

### *Of the General Consideration of this Order of Facts,*

1. IT is not sufficient to have enunciated in the preceding article the general nature of the animal compounds: to know what they are formed of in general, gives indeed a notion of their difference from vegetables, and of their particular mode of existence; but this notion can only be considered as an introduction to their chemical history, or as a first means of arriving at the exposition of the latter. It conducts us to it without being able to supply its want; it may precede it, but it cannot be substituted in its place. When once well conceived, it leads to the understanding of the real chemical properties of animal matters; but alone it will never constitute them; it must even demand that we should pass from the general consideration of this composition to the exhibition of the properties of the animal matters.

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2. In fact, when we know the nature of the principles which enter into the composition of the animal substances, we may explain the phenomena which they present when placed in contact with different other matters ; and it is those phenomena, and their manner of comporting themselves with the different agents by which they are treated, that constitute the chemical properties of these substances. There are two methods of considering these properties : we may either treat of those that belong to the totality of these substances, and are found in all in a more or less remarkable degree, or we may occupy ourselves with these properties with relation to individual animal matters ; and these contain the characters which distinguish each of them in particular. The first constitute the object of this second order of facts : the others shall be examined in the third order.

3. As to the properties of the first kind, or those which belong in general to all animal substances, only a very small portion was formerly known of those which have been discovered within about twelve years past ; chemists occupied themselves with scarcely more than one of the products obtained from them by the action of fire, and the phenomena which their putrefaction exhibited ; namely, the production of what was called *volatile spirit* and *volatile salt*, and which, as we shall soon see, is only carbonate of ammonia by distillation. It was only by this character that animal substances were then

then distinguished from the vegetable; but since the modern discoveries there exists a much greater number of distinctive characters; for the mode of action of most bodies upon the animal substances furnishes as many characters proper for distinguishing them.

4. Though these general properties may now be very much multiplied, and divided into as many species as there are bodies that act differently upon the animal matters, it is easy to refer them to a certain number of heads, which I reduce into nine articles.

In the first, I shall treat of the action of caloric upon these substances.

In the second, I shall examine that of the air.

In the third, that of water.

The fourth shall have for its object the action of the acids.

The fifth, that of the alkalis.

To the sixth will belong the properties which animal substances present with the salts, and the metallic oxides and solutions.

To the seventh I shall refer those which arise from the action of the vegetable substances.

In the eighth I shall examine the acidifiable property of animal substances, and the principal acids which they afford, especially the Prussic acid.

Lastly, the ninth article shall be appropriated to the examination of putrefaction.

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It must be evident that these nine titles comprehend the action of all the classes, or all the genera of bodies upon the substances with which I am engaged, and that such a division can leave nothing to be desired relative to their general and characteristic properties.

## ARTICLE II.

*Of the Properties derived from the Action of Caloric upon Animal Substances in general.*

1. CALORIC acts upon the animal substances by decomposing them more or less rapidly, by changing the combination of their principles, by separating from them products which did not exist as such in these matters. This general action so far resembles that which this agent exerts upon the vegetable substances; it resembles it by tending alike to their destruction; by insulating their principles, by uniting them in another order, by destroying the homogenous composition of which they were formed. But the analogy soon disappears in a great measure, when we examine with attention what passes in this ingenious decomposition; the phenomena are extremely different, and the greater complication of effects which take place are adapted to throw the greatest light upon  
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upon the nature of their primitive composition itself. The discoveries to which the attentive observation of this phenomenon has given rise, and the influence which they have had upon our knowledge of the animal matters, are among the most happy and most useful results of the modern chemistry and the pneumatic doctrine, to which we are indebted for these discoveries.

2. Though the action of a mild heat, and the introduction of a small quantity of caloric into the animal matters, is in general confined, as with the vegetable matters, to thickening their liquids, giving them the concrete form, drying their solids, extracting from the one as well as from the others, a more or less considerable quantity of water, as it is obtained on the water-bath; yet this action, feeble as it is, presents very remarkable differences, which become distinct characters of animal substances. A gentle fire tends to coagulate those that are liquid, and this coagulation is accompanied with opacity and a change of nature; this is announced by the change of taste, and by the insolubility in water which these coagulated matters acquire. The water, which is disengaged on the water-bath, is in part contained in these matters, and in part formed by the action of the fire; it has a particular faint taste; it contains some matters which give it the property of becoming turbid, of depositing flakes, and of putrefying much more

more strongly and quickly than that which is obtained from the vegetables. The animal solids, if heated not very violently, experience a change of colour, of consistence, of tenacity, of smell, and of taste, which is known by the name of *baking*, and proceeds from a commencement of alteration which has not yet been exactly determined.

3. The difference of the action of caloric is much more considerable, when we expose the animal compounds to a more active fire, and to the contact of combustible substances in the state of inflammation or ignited to redness. We see these substances become agitated, contorted, and bend themselves in different directions, so as to exhibit a remains of irritability, or mobility, to this decomposing stimulus; we might say, that, though dead, they still oppose some resistance to their destruction. When this almost convulsive stimulus has abated, the substances thus heated with a naked fire, and in an open apparatus with the contact of the air, become softened, or melted, swell, exhale an abundant vapour, or smoke, of a white, yellowish, or reddish colour, which diffuses a fetid smell known to every one, and greatly differing from that perceived in the vegetable matters when treated in the same manner. — Almost always an ardent and lively flame succeeds these first effects, and the reduction into coal or ashes, more or less coloured, which terminates them, less speedily and less easily than happens in the vegetables,

tables, indicates the presence of an oily substance, whatever the animal body may originally be which is treated in this manner.

4. When animal compounds are heated in a retort of luted glass or porcelain, to which is adapted a receiver, provided with a pneumato-chemical apparatus, we at first obtain a more or less abundant quantity of water, according to the liquid, soft, or viscous state of these compounds. This water soon comes over brown and turbid; it contains different ammoniacal salts; it is soon accompanied with carbonate of ammonia, which dissolves in it at first, and afterwards crystallizes upon the neck of the retort and the sides of the receiver. This second product is succeeded by oil, which becomes more coloured and consistent towards the end of the operation; whilst it passes no water is disengaged, or but very little. The oil is accompanied with carbonate of ammonia, which continues to be sublimed, and part of which is melted and dissolved by the very hot oily vapour. At the same time gases more or less abundant are developed, and collected in the bell-glasses, which terminate the apparatus: if we cause them to pass through lime water, or the metallic solutions, or the oxygenated muriatic acid, they precipitate the first in chalk, the second in coloured fulphurets, and they deposit drops of oil and coaly powders in the third. When the retort which is employed in this operation



operation is heated to such a degree as to become ignited at the bottom, we no longer perceive any thing disengaged, either in the aërial, liquid, or solid form; the white vapour which fills the apparatuses of the receivers diminishes and is condensed, even though the fire be very violent. The fire is then put out, and the vessels are left to cool; they are afterwards unluted, and the products are examined after they have been separated, either by their different place in the vessels of the apparatus, or by pouring them into a funnel, where each assumes a position relative to its specific gravity. Thus are obtained coloured water, concrete volatile salt, animal oil, gases and coal. Each of these products merits a particular examination.

5. The water, as I have already announced, varies in quantity according to the state of the animal matter. It is, however, here supposed to proceed from a dry matter; for liquids are treated on the water-bath, and coagulated, or inspissated before they are treated in the retort. This water was not contained intire in the animal matter, but a great part of it is formed, as I shall show hereafter. Here we speak only of its nature. Its colour, which is red, or yellow, or brown, its fetid smell, its acrid taste, its turbid state, prove sufficiently that it is not pure water. When it is distilled with a double heat, or rectified, though carbonate of ammonia is frequently separated from it, it generally

generally passes more clear, and even transparent. When it is treated with lime, ammonia is disengaged; with the metallic solutions it renders them turbid and precipitates them; with the phosphoric acid, after the lime, and by submitting it to solution, a particular acid liquor is obtained, which Citizen Berthollet has discovered to be a new acid, and which he has termed the *zoonic acid*. In a word, we find in it an ammoniacal soap which colours it, and several ammoniacal salts which may exist to the number of five different species; namely, muriate of ammonia, and carbonate of ammonia, which we already know; zoonate of ammonia, prussiate of ammonia, and sebate of ammonia, which I shall describe elsewhere as particular animal salts. These five salts are not constantly found in the liquid product of the distillation of all the animal substances; but it always contains carbonate of ammonia and ammoniacal salt. There are some animal matters which, after fermentation, yield ammoniacal acetite, instead of carbonate, or at the same time with the latter. It is evident that this very complicated product, which was formerly called *volatile animal oil*, and was employed in medicine, was then very little known, and that its singular nature was not suspected.

6. The concrete and crystallized volatile salt, which is obtained of ammoniacal carbonate more or less soiled by empyreumatic oil. The ammonia is here a product of the fire; it does not

exist previous to its action in the greater number of animal substances. It has already been seen that its production has long been considered as the principal distinctive character of those substances; but its source has only been known since the discovery of Cuthbert Berthollet, relative to the nature of this alkali, which is composed of five parts of azote, and one of hydrogen. It is evident that it is formed by the immediate union of these two principles, at the time when the greater part of the water already formed, leaves free hydrogen, and when a very high temperature augments the attraction of the oxygen for the carbon. Accordingly, there is produced at the same time carbonic acid, which saturates this volatile alkali. This ammoniacal carbonate is rectified by subliming it with a gentle fire. The formation of the three other acids frequently also accompanies that of the ammonia, which in part unites with them; and this formation is owing to the combination of three simple combustible bases with oxygen, as I shall explain elsewhere. Formerly great virtues were attributed to this more or less oily carbonate of ammonia; it was believed that it carried off from each animal matter from which it was obtained, some principle which gave it particular characters: such was that of the viper, of hartshorn, &c. At present it is known that it is one and the same, from whatever matter it has been extracted. We shall see hereafter, that though all the animal

matters equally furnish this product, they greatly differ from each other with respect to the proportion in which they afford it. It is also to be remarked, that some of the immediate materials of plants, especially the extract, the tannin, the gluten, &c. and some entire plants, amongst which are to be distinguished the cruciferous, the papaveraceous plants, the funguses, the nitrous plants in general, yield carbonate of ammonia in distillation, and that this property, which they owe to their containing azote amongst their principles, was the reason why they were called in the school of Rouelle by the not improper name of *animal plants*, though it was not known in this school from what source that product proceeded.

7. The oil obtained in the distillation of the animal matters was no more contained in these matters than the ammonia which is volatilized from them; it is equally a product of the action of caloric upon their principles. It is formed at the time when a large portion of the oxygen of these matters, absorbed by the hydrogen to form the water which passes over first, leaves in the residuum a greater proportion of hydrogen which approaches this residuum to the oily state. This oil differs from that which the vegetables, treated in the same manner, afford, by its abundance, its thick, concrete state, and its ammoniacal nature; it turns the blue vegetable colours green; it has a fetid and very tenacious smell. Dippel, a chemist of Berlin,

was the first who rectified this oil for medicinal use: it has therefore been called by his name. This rectification consists in distilling it with a mild heat, not exceeding the temperature of boiling water, and which is still better, from this liquid itself introduced into a retort with the oil, as Rouelle has recommended. The rectified animal oil is white, very liquid, very odorous, and very volatile; it is quickly turned yellow and brown by the contact of the air, and the light. Carbon which colours it, is separated from it.

8. The gases which are disengaged from animal matters treated in the retort, which Hales had considered to be air, and which induced him to assert that this principle was the cause of their solidity, because at the moment when they escape, these matters generally lose their coherence, are mixtures of carbonated hydrogen gas, frequently sulphurated, and even phosphorated at the same time, and carbonic acid gas. They are very fetid, very combustible, and they frequently burn with an oily flame: to these is owing the infected odour diffused by the animal matters which are burned in the air, or which are distilled in ill-closed vessels, as well as when the vessels in which their products have been received are unluted. When these gases are kept for a long time under water, it becomes turbid; there is frequently deposited upon the sides of the vessel a carbonous and sulphureous crust, of a blackish brown

brown colour; frequently, also, we perceive drops of a thick brown oil, precipitated and attached to the glass; which proves that these gases carry off a portion of this body in solution. If we make them pass into lime water, they precipitate it in calcareous carbonate; in a nitric solution of lead, they form a blackish brown precipitate; when they pass into oxygenated muriatic acid, carbon is separated and precipitated in the liquor. They have been examined and analyzed by detonation with oxygen gas in Volta's eudiometer, after the carbonic acid had been separated from them by a caustic alkaline ley. It was in this manner that Citizen Berthollet ascertained their nature.

9. The coal which remains in the retort after the distillation of an animal matter, very rarely retains the primitive form of this matter; for it becomes softened, fused, and swelled by the action of the fire. It is more dense, more solid, and adheres more firmly to the glass than that of the vegetable substances; frequently it even forms one substance with the retort, so that its weight cannot be ascertained, unless the vessel has been weighed previous to the operation, and weighed again at the termination of the process. Its proportion is in general less than that of the vegetable coals; it is rarely, or hardly ever inflated or cavernous, at least unless an albuminous or saponaceous liquid has been distilled; in the latter case also, we frequently find only a coally layer,



layer, which occupies more space in the retort. Sometimes the animal coal is brilliant, of a metallic appearance, and it is then found very analogous to the carburet of iron. Its combustibility is in general very slight; it must be kept at a strong red heat, and agitated for a long time in contact with the air, in order to reduce it into ashes; it is not seen to burn sensibly, and become covered with a layer of ashes, like that of the vegetables. The strong fire necessary for its incineration, frequently changes the nature of its residuum and volatilizes a part of its salts. Soda and muriate of soda are disengaged from it; the phosphates which it contains are vitrified. Accordingly Citizen Berthollet, in order to analyse the animal coals, has employed nitrate of pot-ash, by causing them to detonate in vessels proper for collecting the elastic fluid products, and the pulverulent residues. I have employed the super-oxygenated muriate of pot-ash for the same purpose. This character of incombustibility, which so eminently distinguishes the animal coals, proceeds from the little carbon which they contain, the density which it preserves in them, its union with the phosphates of soda and of lime, and the oxides of iron and manganese, which envelop and condense it.

10. All the effects of fire upon the animal matters, which I have just described, all the products which I have examined, prove that caloric, by changing the nature of these matters, and making a complicated analysis of them,

them, combines their constituent principles in another order, and that finding them more numerous than those of the vegetable substances, it gives rise to a greater number of new compounds. Water is formed in them less abundantly, oil in larger quantity; ammonia, especially in considerable quantity, exclusively belongs to them; the acids which unite with them, all announce, like the ammonia, an abundant source of azote. Less carbonic acid, and more hydrogen gas than in the products of vegetables, indicate a smaller proportion of carbon, and a larger of hydrogen in the animal substances. The sulphur and the phosphorus which modify their gases, announce the presence of these two combustibles in these substances. This series of the effects of fire, and of the products to which it gives rise, proceeds, therefore, from the primitive complication of the animal compounds, from the multiplied action of their principles upon one another, and from the more numerous attractions which they reciprocally exert. None of these effects of caloric, which are very well adapted for elucidating the nature of these compounds, though they were formerly believed to be very obscure and almost inexplicable, is at present attended with any real difficulty, and it is one of the finest results of the pneumatic chemistry, to have afforded a clear and easily intelligible explanation of them. It has been able to derive great advantage from what had long been only a source of errors and of obstacles to its progress.



## ARTICLE III.

*Of the Properties of Animal Matters treated  
by the Air.*

1. THE properties which the animal matters present, when exposed to the contact of the air, and by the effect of this exposure itself, are less general and less constant than those which are produced in them by the action of fire; they vary much more amongst themselves, according to the differently modified nature of these matters, than the preceding. . In general, those which are solid undergo very little alteration, or a very slow alteration by the contact of the air; the liquid animal substances are almost exclusively and much more sensibly changed by the impression of the air; and it is according to these changes that I shall here announce the properties of these matters, referring them to a certain number of general heads.

2. I find six different effects produced by the air upon animal substances, independant, indeed, of those which it can produce in the living animals; for the general characters of the substances which I examine are taken more especially in their dead state; the vital motion causes them to vary, or renders them complicated, and we must first determine what takes place

place in them without the vital principle which animates them, before we can treat of the phenomena which accompany their living state. These six effects refer 1, to the absorption of oxygen; 2, to the concretion which it produces in them; 3, to the colouration to which it gives rise; 4, to the slow combustion which it excites in them; 5, to the alteration which it experiences itself; 6, finally, to the decomposition which they suffer by the internal motion which it excites in them. I shall recapitulate each of these effects in succession.

3. Almost all the animal liquids have the property of absorbing the atmospherical oxygen gas; those which are viscid, gluey, or saponaceous, possess it in a pretty high degree. This is proved by leaving them exposed to the air in inverted jars, suffering them to elevate themselves in these vessels, and afterwards examining the residual gas by the endiometrical processes. We find that it contains much azote gas, and that it is sometimes even reduced to this gas in a pure state, when the exposure to the air has been long continued. The absorbed gas remains simply condensed, and particularly combined for some time: accordingly, the oxygenated liquids swell considerably in vacuo or by the action of heat. Gradually the oxygen becomes more solidly fixed, combines intimately with them, and changes their nature by oxidizing them more than they were before.

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4. The concretion of the animal liquids consequent upon the absorption of oxygen is easy to be observed, and leaves no doubt of the existence and reality of this second effect in the white of egg, the serum of the blood, the water of hydropic patients, &c. exposed to the air. We see flakes formed in the liquids, remain suspended in them, and become precipitated. By agitating the liquids in the air, they acquire such a disposition to concretion, that a part becomes solid. In this manner are formed the factitious membranes known at Cos, more than a thousand years ago, and described by Hippocrates. The aerated water produces the same effect by its mixture and agitation with these liquors. White of egg exposed to the air, or eggs that have been kept for some time, boil and harden much more easily than very fresh eggs. This phenomenon is connected with the formation and the regeneration of the epidermis; it explains the *plastic powers* of the ancients; it substitutes a simple physical fact instead of an occult quality; it presents itself in the mechanism of nutrition.

5. A thousand phenomena prove the colouration produced in the animal substances by the contact of the air and by the slow absorption of oxygen. Even the solids are not exempted from this constant effect. Bones and ivory become yellow, the skin turns brown and black in the r; the blood reddens in it and assumes the  
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brilliant purple colour which characterizes it, whilst that part of it which is deprived of the contact of the air remains of a dark, and almost black colour. The white albuminous and gelatinous liquids become yellow; fats acquire a citron or orange-colour; wax and spermaceti become yellow; the colours of the kermes, cochineal, several worms, and some molluscæ acquire their greatest lustre by the contact of the air; the bile, the urine, and the perspiration acquire a more intense colour in the atmosphere; the white discharges from the nose, the lungs, the urethra, from ulcers, become yellow or green; all the marine animal products become darker-coloured and browner when they are taken out of the water and placed in the air; putrefaction is accompanied, and its periods are marked by many different tinges.

6. The first effects which have just been enunciated, whilst they indicate a remarkable attraction between the animal matters and oxygen, show pretty clearly that they represent a kind of slow combustion, which causes them to pass into the state of oxides, and which, in some cases, though indeed rarely, gives them even the character of acids: it is in this manner that the acetous acid is produced in several substances exposed to the air, especially in milk and urine. The disposition to coagulation by the fire, or to spontaneous concrescibility, corresponds with the solid and concrete form which the

the oils assume when they are exposed to it, and represents a real oxidation which has its limits and its termination, at the point when the animal matter which experiences it is saturated, and can no more absorb a larger proportion of oxygen. This analogy with the concreteness of the vegetable oils authorizes us to consider the animal compounds as approaching to the oily character, or very much disposed to assume it.

7. The four phenomena that have been enunciated do not take place without the air itself undergoing a change, a more or less considerable alteration. When an animal matter has been for some time exposed to it, we find this air less charged with oxygen, more saturated with water, containing much carbonic acid, and infected with a disagreeable smell. These four changes correspond with four kinds of effects produced by the animal substances; they immediately absorb a portion of the atmospheric oxygen; their hydrogen burns rapidly and forms water; their carbon destroys also a portion of the oxygen gas, which dissolves and acidifies it; finally, a portion of the animal matter itself, already much altered and corrupted, or at least the sulphurated, phosphorated and carbonated hydrogen gases which are disengaged from it, give the air a very marked character of fetidity. Thus, we conceive the cause of the infection and of the noxious properties which the air acquires in the chambers of  
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of sick persons, in hospitals too confined, &c. and perhaps even the manner in which certain fevers, &c. are communicated.

8. In proportion as animal matters absorb the atmospherical oxygen, they become disposed to concrete, become coloured, experience at first a slow real combustion, and at the same time pour into the air different principles which change its nature, and thus these substances sensibly proceed towards that spontaneous decomposition which tends to destroy them, or to reduce them to more simple, namely, binary compounds. We see them from day to day vary in their consistence, their colour, and their smell; fetid effluvia and gases are disengaged from them; their volume is changed, their principles exhale; there is formed in them water, carbonic acid, ammonia, or nitric acid; in a word, they suffer an intestine motion which destroys them, separates a portion of them in the gaseous form, and leaves a part of their fixed residuum in the state of mould. Putrefaction, one of the most marked characters of the animal compounds, one of the phenomena that most deserve to be studied with attention, will be described in one of the subsequent articles. I have indicated it here only in order to exhibit the series of the effects of air upon these substances; for the contact of air favours and accelerates it.

9. If we compare the six effects here indicated, we find as the result, a great alterability in the animal

tion can load him. There are some animal matters which are always found diluted with water, liquefied by it, and owe to it their state, as well as that mobility which permits their transportation into different parts of the bodies of animals. Most of the animal liquids are easily miscible with water; and if we except the solids, all the animal parts are soluble in this liquid.

3. When we cause hot and boiling water to act upon animal matters, there are several which, though insoluble in this liquid when cold, dissolve in it easily and quickly by means of that activity which the caloric communicates to it. Such are most of the white membranous textures which melt in boiling water, and afterwards form jellies with it by cooling, and glues by evaporation; it is on this account that these textures are called *gelatinous* in chemistry. When we give to the water, by compression in Papin's digester which prevents its evaporation, a much higher temperature than that of boiling water, we at last soften even the bones, and cause them to assume the gelatinous state. The corneous and cartilaginous textures pass into this state still more easily and quickly.

4. There are some animal liquids, analogous to the white of egg, and on that account called *albuminous*, which suffer by the action of hot water below 48 degrees of temperature, a coagulation, an induration, and an opacity with which every

every one is acquainted. This property, which is opposite to the gelatinous solubility, announces, in the substances which are susceptible of it, a very different nature, and it has deservedly occupied much of the attention of chemists and physicians. Whilst the latter have described it as a particular and living power, which they have called *plastic*, the former have discovered that it depends upon the oxygenated state of the animal liquids, or at least that it is consequent to this state; that it is owing, as I have shown in the preceding article, to the intimate combination, the fixation of this principle.

5. That effect of hot water upon the insoluble animal solids which is the most generally known, is the boiling of meat. Chemists, however, have not yet accurately determined the mechanism of this effect. It is known that there is produced by it, in the boiled substances, a diminution of their tenacity, a change of texture, of colour, of taste and smell, which renders them agreeable to the organ of taste and easy of digestion. It appears that the coction or boiling consists in a change of proportion and of state in the animal composition, the fusion of the gelatine, the coagulation of the albumen, and a kind of maceration of the fibrous organisation, which renders them easy to be bruised by the teeth, and reduced into a soft and ductile paste by mastication. This property is very different from the coction which the vegetable



substances undergo, and the change which the latter suffer is very distinct and less sensible to every one. Many vegetable matters may be used as food in their crude state, but the civilized part of the human species cannot eat raw animal substances.

6. Long maceration in water changes also the texture and the nature of animal substances in a manner so different from the effect it produces upon the vegetables, that we must thence derive a very decisive character for establishing a well marked difference between those two classes of organic compounds. Almost all the animal matters, when immersed in water, become converted into a fatty substance, analogous to spermaceti, which I have already indicated by the name of *adipocire*. Ammonia at the same time formed, which is dissolved, and carbonic acid which exhales. It is known that in like circumstances the vegetables blacken and become carbonated. This phenomenon, in the animal matters, depends upon their putrescibility; and it is sufficient here to mention it, since its cause and its results will be treated in a more explicit manner in the article concerning putrefaction.

7. It is evident from these effects of water upon the animal compounds, that the general cause which determines their differences from that which the vegetable matter suffer, depends upon the more complicated composition of those bodies. It is always the smaller propor-

tion of carbon and of oxygen, and the larger of hydrogen and azote, which give rise to the changes that have been mentioned, and the phenomena that have been described. These changes are more numerous, more varied, and more considerable, because they take place in substances, the constituent principles of which are more multiplied, and obey a greater number of attractions at the same time; it is because they take place in substances, the equilibrium of whose composition, is much more easily disturbed than that which exists in the less complicated vegetable compounds.

In this simple explanation we perceive a coincidence which always obtains, between the consequences of the action of water and the effects of the other agents that have been studied in the preceding articles. This coincidence will also be perceived in all the subsequent articles.

#### ARTICLE V.

*Of the Action of the Acids upon Animal Substances, considered as a Character of these Substances.*

1. THE manner in which the acids act upon the animal substances, furnishes chemists at present also with a means of characterising these compounds and appreciating their nature.

The science has made great progress with respect to the knowledge of this action since the establishment of the pneumatic doctrine; and in particular it owes much to the labours of the French chemists, especially those of Citizens Berthollet, Vauquelin, and myself. There are two principal considerations to be presented relative to the action of the acids; the one belongs to all these bodies, and is general amongst them; the other is relative to each of the acids in particular, and differs according to their peculiar nature. I shall follow this two-fold manner of considering them.

2. All the slightly concentrated acids preserve animal matters and guard them against putrefaction; accordingly, they have always been considered as powerful antiseptics, and they have been placed at the head of these medicines. All of them have also the property of coagulating and thickening the albuminous liquids, of rapidly dissolving the gelatinous and membranous organs, of preserving the fluidity of the liquids of the same nature, and of preventing them from concreting by refrigeration, as they are accustomed to do when alone; they also soften and dissolve, with the aid of heat, the fibrous organs, or those which contain in their texture the matter which is called *fibrine*. This solution frequently assumes the tremulous and gelatinous form. They dissolve and in part decompose the solid animal substance, and change its phosphate of lime into acidulous

lous salt. Lastly, all the acids, when left for a long time in contact with most of the soft membranous, or fibrous animal compounds, alter them in the course of time, convert a part of them into ammonia, and are afterwards found more or less saturated with this alkali.

3. The particular action of each acid is determined by its own peculiar nature; it is in general more powerful and more capable of decomposing animal matters, in proportion as the acid itself is more feeble in its intimate composition, and as its radical adheres less strongly with the oxygen. There are some also which, without being so easily decomposed, act upon these matters merely by their acid power. This action varies besides according to the state of concentration of each of these acids,—according to the quantity of acid placed in contact with the animal matters,—according to the more or less solid or soft state of these matters; and lastly, according to the temperature by means of which we cause them to act reciprocally upon one another. Amongst the different acids which exert an influence more or less evident, and considerably different upon the animal compounds, we must particularly distinguish the sulphuric, the nitric, the muriatic, and the oxygenated muriatic acids: they comprehend all that need be considered as to this particular action; for the others, and especially the phosphoric, the acetous, the nitric, the tartarous, and the oxalic, singularly resemble the muriatic.

muriatic. It must not be forgotten that the four first, taken in a diluted state, exert only the general actions which have been indicated above.

4. There was formerly observed in the manner in which the sulphuric acid acts upon animal matters, the softening which they experience, with the more or less intense colouration they undergo: and it was believed that this effect announced a kind of semi-combustion beyond which nothing was apprehended: it was compared with the action of fire. Citizen Vauquelin and myself, on examining the phenomena of this action, discovered that the ancient notion was erroneous, and that there takes place between these substances a series of attractions which change their nature in a very different manner than had been imagined. When we immerse an animal matter, flesh, for example, white of egg, or coagulated blood, into concentrated sulphuric acid, and leave these two bodies to act spontaneously, we first see the animal matter assume successively the fawn, the red, the brown, and the black colours, become softened, divided, dissolved, and form a kind of paste. The mixture becomes heated; nothing is disengaged; and on examining it after the action is terminated, we find sulphuric acid weakened with water, which it did not contain at first; the animal matter is reduced to coal, and fatty particles detach themselves from it. If we analyze the sulphuric acid, we find it in  
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part saturated with ammonia and soda. We therefore find that it has decomposed the animal substance, that it has separated from it hydrogen and oxygen, which have united to form the water necessary for its saturation; that another portion has composed ammonia, a third has passed into the state of fat, and a fourth into that of a coally residuum.

5. When we afterwards dilute the acid with a sufficient quantity of water, then filtrate it in order to separate the fat and coally matter, and analyze the filtrated liquor, we find in it sulphate of ammonia, sulphate of soda, sulphate of lime, and a more or less considerable quantity of acetous acid, which may be obtained by distillation. It is therefore proved, that the sulphuric acid has decomposed the salts of soda and of lime contained in the animal matter, that it has converted it into ammonia, acetous acid, water, fatty matter, and coal. We here find an analogy with its effect upon the vegetable substances described in the preceding section; with very remarkable differences, the formation of ammonia and of fat, and the production of the sulphate of soda and of lime. It would be superfluous to explain in detail the causes of these differences, since what has hitherto been said shows sufficiently that they arise from the azote of the animal matters, the greater proportion of their hydrogen, and the presence of the phosphoric salts.

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6. If instead of leaving the sulphuric acid to act spontaneously upon the animal matters, we assist its action by heat, its effect becomes more rapid and more effectual. It is no longer, as in the former case, merely the tendency of the acid to become saturated with water that effects the decomposition of these substances, and which brings into play the complicated attractions proper for changing their nature. The principles of the sulphuric acid themselves tend to separate; the attraction of the hydrogen and of the carbon of the animal matters for the oxygen of the acid, is augmented by the addition of caloric; a more profound alteration takes place in their nature and composition. There is no longer any oily substance formed, with water simply constituted for the saturation of the acid which no longer retains its character; the animal matter approaches much more to the ultimate term of its decomposition. Accordingly we see an effervescence arise, which is prolonged; carbonic acid gas, sulphureous acid gas, sulphurated and carbonated hydrogen gas disengaged. Much water passes in distillation; for this experiment ought to be made in a distilling apparatus; the acetous acid is destroyed; we obtain sulphate of ammonia, and the quantity of coally residuum is less than in the first case.

7. The nitric acid comports itself in a very different manner with the animal matters, because it is much less powerful and permanent, as  
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an acid, than the sulphuric, and especially because it is infinitely more decomposable and much more oxygenated. It was formerly remarked that it gives to those substances a lemon-yellow colour, and that it does not reduce them to coal like the preceding. Its mode of acting upon the vegetables, which has been explained in detail, in one of the articles of the section relative to them, will here serve me to account for that which it exerts upon the animal matters; we shall observe a more complicated operation; we shall remark in it important results which the pneumatic doctrine has enabled us to deduce from it. When Bergman made known the formation of the acid of sugar, or the oxalic, by the nitric acid, Citizen Berthollet found, in 1777, that silk, wool, the muscles, the skin, the tendons, and the hair, afforded more of it than sugar, and that this quantity sometimes even amounted to more than half of their weight, whereas scarcely a fourth could be obtained from the vegetable matters. He discovered at the same time, and, as we see, at a period already remote (now nearly twenty-two years ago), that there was separated an oil, during the formation of the oxalic acid, from the animal matters, and that this oil yielded ammonia in distillation. This was already a striking difference observed in the action of the nitric acid upon these matters.

8. Eight years after this first discovery, the same chemist made another still much more important



important discovery, relative to the action of the nitric acid upon the animal matters. Having seen that they yielded by this acid, when rather weak, and almost without the addition of heat, a large quantity of azotic gas, he remarked that this property accorded with that of yielding ammonia; that when they had lost their azote they seemed to make a retrograde step toward the vegetable state; that all the substances which furnish ammonia exhale also azotic gas by the action of the nitric acid; that in this action there was disengaged, after this gas, carbonic gas and nitrous gas; that the oxalic acid was then formed, and the fatty matter separated; that when the yellow liquor was evaporated in order to obtain the oxalic acid, acid phosphate of lime remained in the mother water: thus he established a very essential difference between the vegetable and the animal matters. I examined, a short time after this discovery, all the circumstances of the disengagement of azote from animal matters by the nitric acid; I have proved that this acid was not decomposed as long as that disengagement continued, and that it thus belonged to the animal matter; that gelatinous matters afforded less of it than the albuminous, and these less than the fibrous; that the azotic gas thus obtained, had a particular faint odour, analogous to that of animal matters when they begin to become tainted, to that of muriate of ammonia sublimed, of ammonia decomposed by the oxygenated muriatic

muriatic acid, &c.; and that its proportion exactly followed that of the ammonia afforded by each animal matter; that when it had been separated from an animal compound, this was no longer putrescible as before; that this gas was very deleterious, that it appeared to have an influence upon the production of putrid diseases in men exposed to its action. Since my first assertion, some have attempted to make a point of medical theory of this object, and its result has been designated by the name of *septon gas*, given to the azotic gas.

9. In 1790, another discovery presented itself to me in the course of my experiments relative to the action of the nitric acid upon the animal substances; namely, the formation of the Prussic acid, and its disengagement in vapour, easily distinguishable by its strong smell of bitter almonds: as it will be treated of more in detail in one of the subsequent articles, I speak of it here, only in order to complete the enumeration of the principal effects of this acid. We see that those effects consist in a yellow or red colouration, in the disengagement of azote in the state of gas, in the formation of the Prussic acid, of the oxalic acid, of the carbonic acid, and of a fatty matter. The difference of this action from that of the sulphuric acid, consist in the separation of azote, the formation of a thicker oil, of less water, the absence of ammonia, the non-precipitation of carbon, the formation of the oxalic acid; it

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depends evidently upon the greater solubility of the animal matter in this acid, its larger quantity of oxygen, which seizing the principles of this matter, insulates and burns its carbon, employs its hydrogen with a portion of this carbon itself and of the oxygen in the formation of the kind of fat, &c. These united effects are still more numerous and more difficult to be well explained than those produced by the sulphuric acid, as there are more attractions acting at the same time; they are nevertheless very well adapted for making us acquainted with the nature of the animal substances and confirming what has already been enunciated respecting them.

10. The muriatic acid presents nothing particular in its action upon the animal substances, neither do the phosphoric or the vegetable acids; it is only a little more powerful than the latter. They all dissolve the fibrous and muscular part, reduce it into a kind of jelly; and at last they decompose and convert a part into ammonia, which saturates them. They coagulate the albuminous liquids, soften, and in part decompose the bones, as well as the cartilages; they also dissolve the membranous textures. It is believed that this effect takes place during life, by the abuse of the vegetable acids, of the acetic and of the nitric acid, and that it is on this account that persons who take them in abundance grow lean, and lose even a portion of the bulk or of the thickness of their  
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their muscles. With respect to the oxygenated muriatic acid, it acts with a far superior energy upon these substances. At the moment of its contact with those animal liquids, it thickens, coagulates and condenses them into flakes, into mucous fragments, and thus confirms what I have said of the coagulation of this humour by the combination or the fixation of oxygen. It hardens the solids, makes them shrink and contract, weakens their colour without destroying it, and even brightens that of several of them. We shall see hereafter that its powerful action upon the humours and the organs of living animals, is calculated to throw some light, at a future period, upon their functions and physiology.

## ARTICLE VI.

### *Of the Properties of Animal Matters derived from their Alterability by the Alkalis.*

1. THE violent action of the caustic alkalis upon animal substances has long since been observed by chemists; but not knowing then either the pure state of the alkalis, or the intimate nature of the organic compounds, they were neither able to explain this action, nor to avail themselves of it for the purpose of ascertaining the composition of these matters. It was a fact which they had observed, without  
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being able to deduce from it inferences useful for the advancement of the science, and they contented themselves with making some applications of advantage to several of the processes of the arts, such as the employment of fixed alkalis rendered caustic by means of lime, for the purpose of opening issues, extirpating indolent and sceleratous tumours, clearing the fat out of wool, &c. It is only since the rise of the pneumatic doctrine that the action of the alkaline caustics upon animal matters has begun to be known and employed for the purpose of determining their nature.

2. It was first remarked that these re-agents acted in a much more powerful manner upon animal than upon the vegetable substances, and that whilst they dissolved the latter but slowly and with difficulty, they softened and dissolved the former with rapidity: it was also perceived that all animal textures treated by caustic alkaline leys lost their strength and their weight, whilst those of vegetable filaments were but very little altered by them. To this action is to be attributed the kind of greasy and unctuous feel which we perceive when we rub the caustic leys between the fingers; a phenomenon which caused the name of *oil of tartar* to be given to the concentrated solution of pot-ash. This solubility of the animal matters takes place even by the solid fixed alkalis, because they find a sufficiency of water in these matters to

to become first softened and dissolved, whence they are afterwards enabled to act as solvents.

3. In 1782, Citizen Berthollet published a Memoir upon this action of the alkalis: he represented it as the effect of a simple combination, into which the animal matters entered intire: he remarked that wool, silk, flesh, boiled with a concentrated ley of pot-ash, were dissolved in it, deprived it of its causticity, gave it a bitter taste, and a red colour, but did not take carbonic acid from it, as Macbride had believed; that this solution was precipitated by the acids and the metallic salts; that in the latter precipitation, the deposit, composed of animal matter and oxide approaching to the metallic state, was unalterable and not imprutrescible; that it did not precipitate the super-oxygenated muriate of mercury, whilst a solution of sugar and of starch in the same alkali did not destroy its causticity but decomposed this metallic salt; that the animal matter thus saturated the alkali.

4. A phenomenon observed by the same chemist induced me to adopt an opinion different from his; it led me to make a series of experiments which furnished me with another theory, by showing me that something different from a simple solution took place. Citizen Berthollet had remarked that the solution of an animal matter by caustic alkali exhaled a disagreeable putrid smell. I soon found that in fact every substance of this nature disengaged a remarkable quantity of ammonia at the moment when it was

was treated by a strong alkaline ley; that at the same time caloric was disengaged; that the same circumstances took place, though with less energy, with lime, strontian, and barites. As a fresh animal matter does not contain ammonia ready formed, I concluded that it was formed from it by the action of the alkalis, that after this the matter being once dissolved was no longer the same as before its solution, but that its nature was changed. In the preparation of the animal soap which is manufactured according to the recommendation and the advice of Citizen Chaptal, by boiling shreds of woollen stuffs in a strong ley of pot-ash, till it dissolves no more of them, this liquid and coloured soap, useful in the manufactories of flannels, of cloths, and of blankets, retains and gives to the stuffs a disagreeable smell which proceeds from this ammonia that is formed, and is dissipated in the air by much washing.

5. It is easy to conceive that in proportion as ammonia is formed, the animal matter losing five times as much azote as hydrogen, must contain in its portion united with the alkali much more hydrogen than before, and that having thus contracted an oily character its alkaline combination is a real soap; accordingly, all the properties described by Citizen Berthollet in this solution are so many characters of a saponaceous compound. The acids decom-  
it and separate from it a concrete brown  
oil;

oil; the metallic solutions form in it insoluble precipitates of soaps; and the same is the case with the earthy salts. Citizen Chaptal has proposed it to answer the purposes of a real soap in the woollen manufactures. It is evident that there is no proof wanting to my opinion.

6. The red or brown, more or less deep colour which animal substances assume when they are dissolved in the caustic ley of fixed alkalis, indicates also another change of these substances. It is easily conceived that when azote and hydrogen is separated from them to form the ammonia which is disengaged, a portion of insulated carbon must be precipitated, and that the oil then formed must approach to the nature of those which are called empyreumatic. Petit observed, in 1733, in the Memoirs of the Academy of Sciences, that a piece of lapis causticus surrounded with fat and skin, rendered these parts reddish by remaining in them for some hours. Poulletier de la Salle has described, in his Commentary upon the Pharmacopeia of London, experiments made upon the application of the lapis causticus to the skin of a dead body, in which he obtained the same result. This agent, employed with the same care and the same apparatus upon the living subject, produced an eschar, an excavation, with a margin of a livid-red colour, owing to its colouring action upon the subcutaneous fat.

7. This action of the alkalis, which at present is well ascertained, explains their use as



caustics for removing malignant ulcers, indolent humors; it is evident how their employment as solvents for the diseases which require this kind of remedies, may become dangerous if abused; how the alkaline leys alter and weaken all the animal textures which are impregnated with them, or left to remain in them, and especially if heated with these liquors; as is frequently practised with wool, silk, hair, feathers, &c.

## ARTICLE VII.

*Of the Action of the Saline Substances, the Oxides and the Metallic Salts upon Animal Substances, considered as Character of these Substances.*

1. I COMBINE in a single article the action of three kinds of substances upon animal matters, because it is either weak or difficult to be determined, or not yet appreciated with accuracy. There are few facts to be described, and few results to be deduced from the action of these bodies: it was, therefore, necessary that I should consider them together, not to separate them, but associate them in one consideration.

2. The preservative property which the salts show with respect to all the organic substances in general is well known, and a number of arts  
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and processes especially prove the existence of this property with respect to the animal matters. Alum hardens skins and contracts their texture, which it renders more durable; its solution is frequently employed in order to preserve, against every kind of alteration, the organs or the parts of animals in anatomical collections. The muriate of soda produces a similar effect, which preserves meat so well, that it is employed in order to prevent its spoiling and to adapt it for nourishment. The same process is employed for butter and cheese. Pringle imagined that a small dose of salt accelerated their putrefaction, whilst a large one was antiseptic: this opinion has been found to be an error, and that a small quantity of salt suffers the animal matters to putrefy, only because it does not absorb the whole of their humidity.

3. The earthy salts, whilst they present the property of the preceding, exhibit another character in their active energy upon animal matters; they decompose their soluble phosphates, namely, those of soda and ammonia, which are almost constantly contained in the liquors of animals: hence it comes that when we pour solutions of nitrates and muriates of lime, magnesia, or strontian, into the serum, whey, urine, the water of hydropic cases, or water in which flesh has been boiled, &c. a more or less abundant precipitate is produced, which is always phosphate of lime. The soda which exists insulated, or in the saponaceous state in several of these

these liquors and in the bile, also decomposes these salts and precipitates their earthy bases; so that this precipitate is frequently two-fold and consists of earthy phosphates and earth. In the case of the saponaceous animal liquors, the precipitate which is formed is an insoluble earthy soap. The aluminous salts, whilst they produce the same effect upon the coloured liquors, frequently deprive them of their colour, with the matter of which alumine has a strong affinity.

4. It is evident from this exposition that the saline matters have almost always a very complicated effect upon the liquid animal substances, a part of the salts of which they decompose, becoming decomposed themselves, especially when they are of an earthy nature, and that they preserve these matters when solid, and condense their texture. We must, therefore, confine ourselves to these effects the generality which it is here necessary to present; we shall hereafter have occasion to give an account of some other actions exerted by the salts upon several animal substances in particular, to show that these actions depend upon the special nature of these substances, and that they ought to be considered as very proper for characterising them. It can scarcely be doubted that many salts with an alkaline base, which are not found in the animal compounds, produce in these compounds phenomena of decomposition, or of triple and per-quadruple union, which have not yet been deter-

determined. Much still remains to be done for the Science in all these respects.

5. Those metals which are the most easily oxidized undergo this kind of alteration, when they are kept immersed in several animal liquids. Iron, zinc, lead, and copper belong especially to this order; their oxidation is more particularly speedy and more marked in the albuminous liquors. This slow combustion is frequently succeeded by a real phosphatization, by the union of the metallic oxides with the phosphoric acid of the animal matters. Every one knows how easily silver becomes coloured and blackened by the contact of these matters, and even of the vapours which exhale from them. The sulphurated hydrogen gas with which they are frequently charged is the source of this alteration; the sulphur which abandons it, unites in the course of time with this metal, and it was the cause of the sulphuret of silver formed by plates of this metal, which had remained for a long time in a privy at Compeigne, and were examined in 1765 by Macquer. Even the metals that are the least easy to be oxidated, nevertheless assume this state by trituration with those animal liquors which quickly absorb this principle. It is in this manner that mercury, gold and silver, triturated with saliva and fat, are converted in a longer or shorter time into real oxides when they have the contact of the air.

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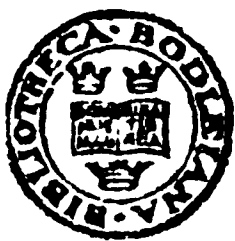
6. The highly oxidized metallic oxides, on the contrary, yield a more or less considerable portion of their oxygen to the animal matters with which they are placed in contact. It is in this manner that those of mercury and of silver thicken and coagulate the albumen: some of those which adhere the least with it, and suffer it to be taken from them with more or less facility, even burn the animal compounds. Acknowledged as caustics, when they are applied to these compounds in the living state, they may serve for making their analysis when they are deprived of life. The animal matters are reduced into coal by the action of these oxides; whilst it takes place water is formed, sometimes ammonia, and in other circumstances, nitric acid. It is on this account that the red oxide of iron, mixed with the animal substances employed in the artificial nitre-beds, contributes to the formation of this acid.

7. The solutions of the metals in the acids, act by both their component parts upon the animal liquors; there is not one of them that is not decomposed, and the oxide of which is not separated and approached to the metallic state, by remaining in this liquor. Those of the white metals, and especially of mercury, and lead, and of silver, are precipitated at the very moment of their mixture with these liquors. This precipitate is formed either by the muriatic acid, or by the phosphoric acid, which in part of the elements of these matters; the  
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soda which they contain, also contributes to it; the albumen, which frequently constitutes a portion of them, by taking oxygen from the oxides of the solutions also produces their separation from the acid: sometimes even the sulphurated hydrogen dissolved in the animal liquids, enters for something into the precipitation; so that the precipitates obtained in these operations may be composed of five different matters; namely, of a phosphate, a muriate, a simple metallic oxide, and the same oxide albuminated and sulphurated: a delicate analysis made slowly by means of different acids, may exhibit each of these metallic precipitates, and even give the proportions.

8. The action of the metals and of the metallic oxides and solutions upon the animal solids, has not yet been examined with sufficient accuracy for it to be possible to describe it with exactness. It is known that these solids are preserved by these solutions; that they become coloured, condensed, contracted, and hardened; that they absorb a portion of the metallic salt; that they decompose another and separate from it the oxide which they approach to the metallic state; that they at the same time suffer an alteration more or less considerable, according to the differently concentrated state of the solution, and that in the frequently dark colour which they acquire, their carbon is insulated, and their hydrogen burned. The most acrid and most caustic solutions burn and entirely destroy the texture of the animal solids,

solids, by reducing them to a complete coally state: it is for this purpose that they are employed in surgery.



## ARTICLE VIII.

*Of the Action of Vegetable Matters upon the Animal Substances, considered as Generic Characters of the latter.*

1. THE entire vegetables, or the different immediate materials of vegetables, have not nearly so powerful an action upon the animal substances as that which they exert upon most of the preceding substances; the effect which they produce upon them is frequently almost insensible. It is not observed, that they tend to disorganize them, to decompose them, or to destroy the equilibrium which exists between their constituent principles; we consequently find that they cannot be used for analyzing them. This action, however, is not a nullity; though it is feeble, it does not the less merit to be examined with attention, and described with care: we find in it phenomena which may add to the chemical characters of the animal substances, and contribute to the understanding of their nature.

2. Formerly we judged by the taste of plants of their medicinal virtues, which some physicians had attributed to their chemical properties; but the erroneous notions which they had formed of the analogies of these two kinds of properties

perties are now banished by a sound theory ; and they no longer form a part of the science. It was thought that the juices of the vegetables mixed with the animal liquors ought also to show, in their sensible action upon these liquids, the nature of their action in diseases ; some were solvent or attenuant, others inspissant and incrassant, some anti-putrescent, others astringent and condensing, others again septic. It has been ascertained that these experiments were not only mere chimeras as to the therapeutic theory, but also real errors with respect to the chemical effects, which are still too much complicated, even at the present day, when the science is so much farther advanced, to be capable of being well determined.

3. We may with greater facility appreciate the immediate, though feeble effects, produced by the immediate materials of plants, when sufficiently pure and insulated, upon the animal matters. The mucilages dissolve in their liquids, and frequently precipitate from them such materials as are less soluble than those which they contain. Sugar, whilst it produces this first effect, acts besides as a preserver : sometimes by its solution it favours the alterability and fermentability of which they are susceptible. It has already been seen that the vegetable acids coagulate the albumen, dissolve the fibrin and the gelatin, and prevent or retard their alterations.

4. All the inflammable oily bodies, all the materials of vegetables in which hydrogen appears



pears to be the superabundant principle, act in an uniform manner upon the animal substances. When covered with fixed oil, they keep, and frequently suffer themselves to be penetrated by it, like the skins which thus acquire pliability; the animal mucilages, the albumen, and the gelatin, render it miscible with water by agitation, and suspend it in emulsion; oil dissolves the fats with the aid of heat.

The volatile oils, the balsams, the resins, camphor, preserve the animal substances from putrefaction: on this account they were employed by the nations of antiquity for the purpose of preserving dead bodies in embalming.

So strong and so marked an attraction is observed between the vegetable colouring matters and the animal textures; and this is so well demonstrated by the solidity of the dyes applied to wool, silk, &c., that in order to make vegetable threads approach to the same solidity, they are successfully impregnated with fat or animal oil, which disposes the colouring matter to adhere to them.

The ligneous matter itself, however inert it may appear, is not entirely void of action upon the animal matters: when reduced into powder and thrown upon their surface, it dries it, absorbs their moisture, hardens them and preserves them from alteration.

5. The different vegetable materials hitherto indicated are almost inert in comparison with three other vegetable substances, the energy of which

which upon the animal compounds is infinitely stronger: these are the tannin, the gallin, and alcohol; each of them deserves to be examined separately. I have already upon a former occasion spoken of the nature and general property of tannin; and I must hereafter treat with some detail of the cutaneous texture; it will, therefore, be useful here only to state the general impression which the animal matters experience from this substance. Tannin dissolved in water precipitates the albumen and gelatin from their natural solutions or from the animal liquids which contain them. The precipitate, especially that of the gelatin or glue, is soft, fawn coloured, ductile; it hardens and becomes brittle by drying: it is then insoluble and unalterable. This precipitation is so well adapted for characterizing the animal substances and especially the gelatin, that by its quantity we may determine that of this principle as well as ascertain its presence. It is also found that tannin, which has become an useful re-agent in the animal analysis, is the most powerful of the vegetable antiseptics, since tanned skins experience no more sensible alteration and keep a long time without change. This property will, at some future period, afford an useful application to medicine; it may already be employed with advantage for anatomical preparations and for preserving membranous organs.

6. *Gallin* I term the impure gallic acid, combined with a small portion of extractive, or of a vegetable principle hitherto unknown, in which its astringent taste principally resides. It exists almost always along with the tannin; it is not absorbed by the animal matters, nor precipitated by the solution of glue: so that water saturated with tan, and afterwards deprived of tannin by the skins which have taken it from it, contains this gallin which is exhibited in it by precipitating the sulphate of iron. Mr. Proust has separated the gallin from the tannin, both contained together in a decoction of gall-nuts, by uniting it with muriate of tin which seizes the tannin by which the oxide of tin is precipitated, and leaves in the supernatant liquor the gallin with the muriatic acid. Citizen Seguin has discovered in the gallin the property of disoxygenating or unburning animal matters, and of distending them, by swelling them in such a manner as to dispose them by this double effect to combine with the tannin. The use of the gallin as a re-agent may hereafter be carried so far as to enable us by its means to ascertain the state of oxygenation of the different animal substances.

7. Alcohol, the product of a spontaneous alteration of the saccharine matter that has been elsewhere described, has itself a very marked action upon the animal compounds; its effect is fourfold upon these compounds according to their different nature: it dissolves some  
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and may serve to separate them; it coagulates others; some it preserves and even hardens their texture.

It effects the solution of the animal resins, of some colouring parts of animals, of several of their acids, of certain fats, especially of that which I call *adipocire*, and which is found in the dried liver, in biliary calculi, &c.

It coagulates the albuminous liquids; it precipitates from them the albumen in small flakes almost pulverulent which may be dissolved in water, as Bucquet has remarked, at the moment when they have just been precipitated.

It preserves and defends against putrefaction almost all the animal matters liquid or solid: it is employed for this purpose in anatomical laboratories, and even in medicine.

Finally, it hardens the texture, contracts and condenses the fibres of most of the solids of animals; it condenses and hardens their plates and laminae.

## ARTICLE IX.

*Of the Property of Forming Prussic Acid and some other Acids, considered as Character of the Animal Compounds.*

1. **THOUGH** the discovery of Prussian blue, made in the first years of the eighteenth century by Diesbach and Dippel, two chemists of Berlin, had at first only a colouring matter useful in painting for its object, it might since that time be thought that it would have a direct influence upon animal chemistry, as it really belongs to the substances of this nature, and was made by a chemist who had much occupied himself with these substances. However its relations with this kind of analysis, and the characters which I now derive from it in order to distinguish the animal substances, were not very perceptible till after the experiments of Citizen Berthollet in 1787, and especially till after a discovery made by myself, in 1790, upon the production of the Prussic acid, during the treatment of animal matters by the nitric acid. It required the labours of nearly eighty years to ascertain this influence; and this is the reason why I think it incumbent upon me to give a somewhat detailed history of these labours

labours, or at least of the principal epochas which constitute it.

2. It was a little before the year 1710, that Diesbach, having borrowed from Dippel some alkali, in order to precipitate a lake, or extract from sulphate of iron, accidentally obtained a very beautiful blue. The latter chemist, knowing that this alkali had repeatedly served him for distilling and rectifying animal oils, easily reproduced this colour by precipitating sulphate of iron with a similar alkali. This discovery was announced in the Memoirs of the Academy of Berlin, in 1710. In 1724, Woodward described, in the Philosophical Transactions, the first process for preparing this new blue, which made much noise. It consisted in calcining in a crucible equal parts of ox-blood and pot-ash to redness, lixiviating the product with boiling water, mixing this lixivium with a solution of sulphate of iron and of alum, and employing muriatic acid in order to brighten the blue, which was washed with a large quantity of water. This very good process is still in a great measure followed in the workshops. The name of *lixivium of blood* was given to the liquor obtained from the alkali treated with this substance, afterwards dissolved in water, and thus disposed to precipitate the iron in the blue state.

3. The chemists zealously laboured upon this process, and at first sought various means for rendering the alkali capable of producing this colour.

colour. Brown, in 1724, found that the alkali treated with flesh acquired this property in the same manner as with blood; and he endeavoured to explain its formation by means of a bituminous principle of iron, developed by the blood, and fixed upon the alumine. Geoffroy, the physician, discovered in 1725, that oil, wool, hartshorn, sponge, and even thymol calcined with alkali, give it the same action upon the sulphate of iron; he thence explained the blue before described in soda treated with the acids by Henckel: and he adopted the theory of Brown. Neuman endeavoured to treat the alkali with many different oils, and succeeded in communicating to it the tinging property by these inflammable bodies. Menon gave, in the *Memoirs des Savans étrangers* of the Academy of Sciences of Paris, a new theory of Prussian blue: he pretended that blue was the natural colour of iron, and that blood insuluted it by purifying or refining this metal. Thus forty years passed without any other notion being added to the first discovery, except the possibility of obtaining blue with various matters different from blood, especially animal substances.

4. In 1752, Macquer, in an excellent *Memoir*, inserted amongst those of the Academy of Sciences, advanced the theory of this preparation a considerable step farther, by discovering the discolouration of Prussian blue by the alkalis. He showed that the alkaline leys became saturated with

this colouring matter, by causing them to pass over Prussian blue till they ceased to discolour it, and again formed an abundant quantity of pure blue, when they were poured into a solution of sulphate of iron; that these saturated leys were in a state different from that of the immediate ley of blood, as this did not directly precipitate the iron into the blue, but in the grey or green state, on account of the portion of alkali not saturated. He suspected that the colouring matter saturated the alkalis after the manner of an acid; that it adhered to them much in the same manner as to iron, since the simple acids, according to him, did not disengage it from them; that in order to take it from them and transfer it to the iron, it was necessary to employ a double affinity. He substituted, instead of the vague theory of Brown and Menon, that of the alkali saturated by *phlogiston*; this was transferred again to the iron, which it surcharged by separating it from the acids.

5. More than twenty years elapsed after the ingenious labours of Macquer, without any thing being added to his doctrine, which was adopted by almost all the chemists, who were then satisfied with it. They contented themselves with prosecuting their researches concerning the bodies capable of *phlogisticating*, as they expressed it, the alkali; Weifman found this property in the empyreumatic oils; Model, in foot; Cartheuser in several vegetable ashes;



colour. Brown, in 1724, found that the treated with flesh acquired this property in the same manner as with blood; and he endeavoured to explain its formation by means of the minous principle of iron, developed in blood, and fixed upon the alumine. (C. the physician, discovered in 1725, that wool, hartshorn, sponge, and even calcined with alkali, give it the same colour upon the sulphate of iron; he thence deduced the blue before described in solution with the acids by Henckel: and he published the theory of Brown. Neuman endeavoured to treat the alkali with many different substances, succeeded in communicating to it the property by these inflammable bodies, and gave, in the *Memoirs des Savans*, the theory of Prussian blue: he pretended that it was the natural colour of iron, and insulated it by purifying or reprecipitating. Thus forty years passed without any new notion being added to it, except the possibility of communicating it to various matters different from the animal substances.

4. In 1752, Macquer, in his *Memoir*, inserted among the *Sciences*, advanced the theory of Prussian blue, and considered it as a compound of iron and phosphorus.

occupied themselves with this substance. This celebrated chemist undertook to ascertain, both the compounds of which the Prussic acid forms a part, the properties of this acid, which before him no one had been able to insulate, and its intimate nature, by decomposing it, and also by forming it in a direct way with materials less complicated than the animal substances. His discoveries upon these different points are contained in two Memoirs inserted in the Trimestres of the Academy of Stockholm, of December 1782, and January 1783. He began with examining the ley of blood: he saw that it was altered by the contact of gaseous carbonic acid; that this acid disengaged from it a vapour, which converted sulphate of iron placed upon a stopper at the top of the apparatus into blue; that the sulphuric acid also separated it from it with the aid of distillation; that the Prussian blue, distilled with this acid, yielded an elastic fluid, which tinged the oxide of iron blue; that, when distilled alone, the Prussian blue yielded a portion of this colouring vapour, and ammonia saturated with it; that the ley of blood dissolved a small quantity of oxide of iron, which rendered it more solid and more permanent; that the iron eminently possessed the property of fixing the Prussic acid; that fire and the acids were nevertheless capable of volatilizing this colouring matter; that an alkaline ley, whilst it discoloured the Prussian blue, dissolved a small portion of it entirely, and thus acquired a more durable

character than the ley of blood; that an acid distilled with the prussiate proceeding from the discolouration of the Prussian blue, precipitated from it an abundant quantity of real Prussian blue, because it was decomposable only in its portion of alkaline Prussiate, and not in its ferruginous Prussiate.

8. After having discovered the possibility of obtaining the colouring matter of Prussian blue separate, and being able to observe its properties in its pure state, he sought the most speedy and most certain means of effecting this separation, which till then had been unknown to the chemists, who had not yet had this matter otherwise than combined with the alkalis and the metals: Scheele preferred the following process, which has been practised since his time. Two parts of Prussian blue, and one part of red oxide of mercury, are boiled in six parts of water till the whole is decolourated: to the lixivium is added half a part of iron-filings, and a little less of sulphuric acid; the mixture is distilled, and nearly a fourth of the liquor is drawn off, which is rectified by distilling it again upon chalk, in order to absorb the portion of sulphuric acid which it may contain. In this operation, the oxide of mercury takes away the Prussic acid from the oxide of iron, and is dissolved in Prussiate of mercury, white, crystallizable, &c. The iron, which is added in the metallic state, reduces the oxide of mercury, and at the moment when it unites with the sulphuric acid, added at the same time,

the heat which is employed volatilizes the Prussic acid separated from the mercury, which has been reduced to the metallic state. The Prussic acid thus obtained, partly in liquor and partly in gas, produces, when united with the alkalis, the same effects as the leys of blood and of decolourated Prussian blue. We shall soon return to its distinctive characters.

9. Scheele was not content with having found the means of insulating and obtaining pure the colouring matter of Prussian blue or the Prussic acid; he wished also to ascertain what it was composed of, and consequently to know how it is formed in animal matters. In order to determine its constituent principles, he first observed, that in the process of abstraction the air of the receiver was inflammable; that in decomposing the Prussiates by fire, he obtained ammonia and carbonic acid; that some metals were afterwards found reduced by the distillation of these metallic Prussiates. He then suspected that this acid was composed of ammonia and oil, and directed his subsequent researches upon this supposition; but he could not succeed in forming the colouring compound with ammonia and different oils or fats heated together. Observing that the water was an obstacle to this formation of Prussic acid, he conducted his experiments in a different manner, by uniting ammonia with the dry inflammable principle which he admitted in the oils, and with the carbonic acid also dry. He

of the peach tree, a taste sweetish at first, afterwards acrid and burning, the property of not reddening the blue colours, but of precipitating soap and the alkaline sulphurets, that of combining with the alkalis, and of forming salts capable of precipitating the metallic solutions, and especially those of iron in the blue state. He distinguishes amongst the saline compounds of this acid, the Prussiate of lime, which he recommends, as being very pure, to serve as a test proper for ascertaining and indicating the presence of iron with certainty in waters, &c.; a test which the chemists have sought with much care for a great number of years past. Two years before the labours of Scheele, in 1780, I employed this calcareous Prussiate, in my courses of Lectures, as a test for ascertaining the presence of iron.

11. Such was the state of the Science with respect to the colouring matter of Prussian blue, or the Prussic acid, when Citizen Berthollet communicated, at the close of the year 1787, to the Academy of Sciences, a new inquiry in which he employed with great sagacity, and by the aid of the new data of the French pneumatic doctrine, the experiments of Scheele, adding to them several others, and converted the still uncertain and inadmissible theory of the French chemists into an explanation that agreed much better with the views of the modern chemistry. The result of his inquiry was, as it were, the result of the light which he had thrown

thrown upon the nature of ammonia some years before. The composition of the one, once well known, must in fact have necessarily conducted him to the knowledge of the other, since even the researches of Scheele had already showed a singular analogy between these two compounds, equally abundant amongst the products of the animal matters.

12. The French chemist first proves that the alkaline Prussiate, formed by the discolouration of the Prussian blue, by means of alkali, contains iron; that its lixivium, being evaporated and afterwards re-dissolved, yields octahedral crystals, the points of which are truncated near their bases; that, mixed with sulphuric acid and exposed to the sun, its solution deposits Prussian blue, and is decomposed; which does not happen to it in the same manner in the shade; that the Prussiate of mercury crystallizes in four-sided prisms, terminated by pyramids with four faces corresponding with the edges of the prisms; that the muriatic acid disengages more Prussic acid from it than the sulphuric acid; that this acid, in decomposing the Prussiate of mercury, forms a muriate in a singular state.

13. After these preliminary experiments, he proceeds to the examination of the intimate nature of the Prussic acid by the action which the oxygenated muriatic acid exerts upon it. The latter, in proportion as it dissolves in the Prussic acid, returns to the state of ordinary muriatic

muriatic acid; the Prussic acid becomes more odorous, more volatile, less susceptible of uniting with the alkalis, and precipitates iron in the green state from its solutions. This green precipitate again becomes blue in the light by the contact of the sulphureous acid, by iron: it is the oxygenated *Prussic* acid. By accumulating in it new oxygenated muriatic acid, which is made to pass into it in gas, and by exposing it to the light, water is separated, to the bottom of which it is precipitated in the form of an aromatic oil, which heat reduces into an insoluble vapour, that can no longer unite with iron. Thus super-oxygenated, this acid can no more return to its first state; it is far remote from its primitive nature.

14. The oxygenated Prussiate of iron, which is also prepared by treating the Prussian blue with the oxygenated muriatic acid, and is distinguished by its green colour, loses its acid which is suddenly converted into carbonate of ammonia by the contact of a fixed caustic alkali. The Prussic acid does not contain ammonia ready formed, as Scheele and Bergman thought; it contains only its elements, azote and hydrogen, both combined with carbon. When a sufficient proportion of oxygen is added to this combination, the successive addition of an alkali or of lime quickly destroys the Prussic compound by the pre-disposing attraction which they have for the carbonic acid. Accordingly, Citizen Berthollet has been led by his experiments

ments to consider the Prussic acid as a combination of three simple combustible bodies; hydrogen, carbon and azote, the proportions of which, however, he has not found, though he has announced that those of the hydrogen and azote approach to the ammoniacal composition.

15. This result, which is much more precise than that of the Swedish chemist, has furnished Citizen Berthollet with the means of easily explaining the principal phenomena which the Prussiates present, as well as the formation of the Prussic acid. The following are the facts which he has especially considered under this new point of view:

*A.* The metallic Prussiates distilled, yield carbonated hydrogen gas and carbonate of ammonia, and their oxides are more or less reduced; for the oxygen of the oxides, seizing the carbon, leaves the azote and the hydrogen to unite with one another; the oxygenated muriatic acid acts in the same manner.

*B.* The animal matters form Prussic acid in proportion to the azote they contain, which combines with the hydrogen and carbon.

*C.* In the experiments of Scheele, the muriate of ammonia heated with fixed alkali and charcoal is decomposed: it is by the elements of the ammonia and not by the entire ammonia that this salt contributes to the formation of the Prussic acid.



*D.* The hydrogen, which forms part of this compound, is the cause of the violent inflammation produced especially by the super-oxygenated muriate of pot-ash.

16. Citizen Berthollet, not having found oxygen in his experiments of decomposition upon the Prussic acid, thinks himself authorized to conclude from thence that this acid contains no acidifying principle. On this occasion he examines the singular nature of this compound; though he discovers in its properties very remarkable differences between it and the other acids, he thinks, however, that it approaches the nearest to the nature of these bodies, and that it ought to be ranked in their class. He especially insists upon its analogy with ammonia, and the tendency which it has to pass into the state of this volatile alkali. He terminates his inquiry by the explanation of a very singular phenomenon of attraction which the Prussic acid presents, and which Scheele had considered as an irresoluble problem; namely, that it cannot be separated from the metals by the other acids, and that, nevertheless, it cannot by itself take away from these acids the metallic oxides that are dissolved in them. He explains the apparent contradiction in the doctrine of affinities, by the great quantity of specific caloric which this acid when pure contains, and by the strong tendency which it has to assume the gaseous form.

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17. We see from the ingenious researches of Citizen Berthollet that the production of the Prussic acid by the decomposed animal matters, whilst it exhibits one of the most proper characters for distinguishing them and ascertaining their nature, presents a property singularly related with that of forming ammonia. But in what does this property of affording Prussic acid or ammonia precisely reside? and what is the cause which determines the production of the one rather than the other? In order to solve this question, which is of great importance to Animal Chemistry, it is to be observed, that the formation of ammonia supposes a more advanced decomposition than that of the Prussic acid, as the one represents a binary compound, whereas we still find in the other a ternary compound, more approaching to the nature of the primitive animal matter by its very complication. In the second place, it is to be remarked that the production of the Prussic acid is not sensibly favoured, or does not take place in any abundance except when we treat the animal matters by a fixed alkali, especially aided by a metallic oxide; it is, therefore, the pre-disposing attraction, exerted by two bodies at the same time, which ought to be considered as the cause of this formation of Prussic acid. Finally, it must not be omitted, that the production of the Prussic acid never takes place except in a very small quantity comparatively with that of the animal substances which afford it, that it amounts

amounts only to some thousandths or at most to two or three hundredths; and that the carbonate of ammonia which they afford is in a quantity twice or thrice as considerable, on account of the carbonic acid which saturates it, and which is formed at the same time.

18. In 1790, three years after the inquiry of Citizen Berthollet, I pointed out a new fact, which I thought adapted to elucidate the nature and the formation of the Prussic acid. In treating the serum of coagulated blood by the nitric acid, I was struck with the smell of Prussic acid. The vaporous product disengaged in this experiment having been collected, I found it to be real pure Prussic acid; I even obtained a sufficient quantity of it to induce me to believe that this very simple process might be substituted instead of that of Scheele, which is much more complicated, in order to obtain this acid; azotic gas had been disengaged with it and carbonic acid gas was formed. This led me to think that a simple change in the proportions of the constituent principles of the animal matters was sufficient to give rise to the Prussic acid; and that, as in the formation of the nitric acid, azotic gas had at first been disengaged, there was reason to believe that this acid contained less azote than the ammonia, since in the formation of the latter this principle was not separated before that formation had taken place. It cannot therefore be admitted, either that the Prussic acid is a solution of carbon in ammonia, as Scheele

Scheele had presumed, or that it contains azote and hydrogen in a proportion nearly approaching to that which forms ammonia, as Citizen Berthollet had announced. This opinion of the quantity of azote proportionably larger in the Prussic acid than in ammonia may even be supported by one of the facts which had been well observed by the latter chemist; I mean, the disengagement of a certain quantity of carbonated hydrogen gas during the formation of the carbonate of ammonia, which accompanies the decomposition of the Prussic acid by fire. Neither does it appear to me to be well proved that this acid ought to be considered as wanting oxygen, and as formed merely by the union of three simple combustibles, both because Citizen Berthollet who has proposed this opinion has not made an accurate analysis of this acid, and because the comparison which he has established between this acid, the muriatic acid, and the sulphurated hydrogen, is very far from being equivalent to a proof; and finally, because the constant production of the carbonic acid in all cases of the decomposition of the Prussic acid, even not previously super-oxygenated, the six-times more considerable quantity of Prussic acid obtained by Citizen Vauquelin, in decomposing muriate of ammonia mixed with charcoal by the oxide of lead, than that which he obtained in performing the same operation with lime instead of oxide of lead, militate strongly in favour

favour of the adoption of oxygen in this acidified compound.

19. The formation, the nature and the properties of the Prussic acid, as a characteristic production of the animal compounds, are so necessary to be accurately known in order that we may form a right conception of the properties of these compounds, that it appears indispensable to me here to enumerate the series of properties that belong to this important product, considering it as insulated, and prepared either by the process of Scheele, or by that which I have indicated (No. 18):

*A.* The Prussic acid has a strong odour of peach-blossoms or of bitter almonds. This smell impregnates for some time the saliva of those who respire it.

*B.* Its taste, which at first is sweetish, soon becomes acrid, hot and virulent; it excites coughing.

*C.* It has a great tendency to assume the gaseous form, and frequently some of it is lost in this form in the vessels into which it is received.

*D.* It is decomposed at a high temperature, and by the contact of light: it is thus changed into carbonic acid, ammonia, and carbonated hydrogen gas.

*E.* It combines with the alkaline bases with difficulty, and without destroying their alkaline property.

*F.* Its

*F.* Its weakness, already proved by the preceding property, permits the carbonic acid to displace it from the alkaline Prussiates.

*G.* It takes oxygen from the oxygenated muriatic acid, and its nature is changed by the addition of this principle.

*H.* It does not act upon the metals; it unites with their oxides, the colour of which it changes, and with which it forms in general insoluble salts.

*I.* It has a great propensity to form triple salts with an alkaline and metallic base. These triple Prussiates, these complex combinations are more permanent and more fixed than the simple alkaline Prussiates; they are no more decomposed by the carbonic acid, light, the air and the acids.

*K.* When it is united with the metallic oxides, it cannot be separated from them by the acids, as in these combinations it acquires a great fixity and a great adherency; and yet when it is insulated, it cannot carry off the oxides of the metals from the other acids, on account of its specific caloric, and its tendency to assume the state of gas.

*L.* According to the researches of Citizen Berthollet and Mr. Proust, there are two species of metallic Prussiates, the simple and the super-oxygenated: there is even reason to believe that with respect to iron there are three, the white, the blue and the green, the progression being made from the most to the least oxygenated.

*M.* The

*M.* The super-oxygenated Prussic acid is very near to decomposition; the mere contact of a fixed alkali destroys it and converts it into carbonate of ammonia, because the oxygen being sufficiently abundant, and attracting the carbon, permits the azote to unite in particular with the hydrogen to form ammonia; the hydrogen exceeding the proportion of the latter composition is disengaged in carbonated hydrogen gas.

20. The nature, the composition, the decomposition of this acid being once well demonstrated, its relations with the animal matters which produce it are still better determined by the consideration of the different principal circumstances of its production. I find four of them which equally demonstrate a like series of decomposition that takes place in these matters.

*A.* The action of fire; we have seen that it is obtained amongst the products of the bones, the blood, the urinary calculus; it is combined in them with ammonia.

*B.* The action of the nitric acid; when this acid is weak, it first disengages azote from the animal matters; when it is strong and concentrated, it immediately volatilizes Prussic acid from them, and at the same time are formed carbonic acid, oxalic acid, and the adipocirous matter.

*C.* The action of the fixed alkalis; the animal substances, heated by a strong fire with the alkalis, saturate them in part with Prussic acid after they have been reduced to coal.

*D.* Finally putrefaction, by destroying the animal composition, sometimes gives rise to Prussic acid, which easily finding oxide of iron, combines with it and gives it a blue colour; hence proceed the native Prussian blues described by several naturalists.

21. What I have just set forth concerning the Prussic acid may be applied to some other particular acids of animals, though they be few in number; for we must not rank in this class the oxalic, acetous, sebacic acids, which being found the most frequently amongst the products of the vegetable matters, have the composition and all the chemical characters of such matters. When these acids are formed in the animal substances they really belong only to these matters in a retrogradation towards their first origin, or in some measure descending, by a commencement of decomposition, to the condition of vegetable substances. I know scarcely any other than the zoonic acid discovered by Citizen Berthollet, the uric acid constituting one of the species of the human urinary calculi, and one of the materials of arthritic concretions, the lactic acid, and perhaps the acids of insects, which appear to belong to this class of animal acids, when they do not present all the properties of acetous acid, like the former acid. The most marked character of these animal acids is that they can be converted into Prussic acid by chemical means; they also deserve to be examined under this point of view, especially the zoonic



the lactic, and the uric acids, which are very little known with respect to their intimate composition.

#### ARTICLE X.

##### *Of Putrefaction, considered as Characteristic Property of the Animal Substances.*

1. THE last and one of the most striking characters which distinguish the animal from the vegetable matters, consists in the kind of spontaneous decomposition which they experience, and which is called putrefaction. Though the vegetable substances are not exempted from this decomposition; though nature has subjected them to this law which equally embraces all the organic matters, the slightest observation is sufficient to show that putrefaction is infinitely more powerful and more rapid in the animal compounds, which are more disposed to it by their very composition, and that it establishes itself in them, develops itself and goes through its periods with much greater activity. It is not necessary to present it here as an intestine motion which tends to change the nature of the substances which experience it; for all that has already been said, both in the history of the vegetable substances, and in the preceding articles concerning the animal matters render this sufficiently evident.

2. It is already a long time since philosophers and naturalists have acknowledged all the interest which the study of putrefaction presents for the sciences, and especially for the art of healing. Lord Bacon first pointed out its utility for medicine; he was the first who invited physicians to occupy themselves attentively with it, and especially with the intention of discovering means for preventing it, retarding it, even stopping its progress, or re-establishing the substances which had experienced it in their natural state.

Becher has made a remarkable table of its phenomena, and enunciated its grand effects in the order and succession of the changes which the globe experiences: Stahl his commentator has added nothing to this table.

Pringle, an English physician, has made a great number of experiments upon the septicity and antisepticity of bodies, and has opened an immense career for the doctrine of antiseptics.

Citizen Giobert of Turin has repeated them and added to them several new ones.

A French lady, who has rendered herself eminent by a great number of scientific productions, especially by her translation of Shaw's Course of Chemistry, has given a numerous series of experimental inquiries upon the same subject.

Macbride, a surgeon of Dublin, opened a new career immediately at the first period of the discoveries upon the elastic fluids, in 1766.

He

He established a new theory of putrefaction and the antiputrescents, and attributed the first to the disengagement of fixed air or the carbonic acid and the restoration of the putrid matters to the restitution of this principle. Though this theory has been discovered to be erroneous, since it has been known that the carbonic acid is not contained ready formed in the animal substances, and that it acts only as acid, not as principle of these substances in its antiputrescent energy, yet the efforts of this able chemist have conducted us to new and useful considerations upon this spontaneous motion.

Boissieu, Bordenave and Godart, in three Memoirs which gained the prize and the accessit proposed upon putrefaction in 1767, by the Academy of Dijon, have also given useful observations upon this natural alteration, and have established the basis of doctrine for determining its cause, phenomena and results.

Finally, the labours of the moderns, especially Citizen Berthollet, and the data afforded by the pneumatic doctrine threw a new light upon this kind of fermentation and furnished a more exact explanation of its circumstances and products.

3. A first fact, which must be insisted on, relative to putrefaction, is the extreme facility with which it establishes itself, and the rapidity with which it goes through its periods in the animal substances: the cause of this strong tendency, which is not found in the immediate materials of plants

plants, necessarily depends upon the difference of nature which distinguishes those two classes of organic compounds. It has been seen in all the preceding articles, that the animal composition differs from vegetation by a greater number of constituent principles, and by the proportion of these and the principles that are common to both. The azote added to the hydrogen, the carbon, and the oxygen, the superabundance of the hydrogen in the animal compounds, the phosphorus and sulphur which are very frequently combined with these first principles, complicate their production and are the source of the more numerous and more varied products which are obtained from them by the different agents to which they are exposed. The multiplied attractions which exist between the more numerous constituent elements render the equilibrium more easy to be destroyed, and induce at the slightest variation of circumstances, a decomposition, or change of nature, which quickly gives rise to other products more varied than are obtained from the vegetable substances. Life supports and maintains with more or less force this equilibrium, this permanency of state, and it is in this that it consists; but death permits the first principles to re-act in particular the one upon the other. This spontaneous re-action must then be more prompt, more profound and more effective, as it takes place amongst substances more numerous, and by virtue of attractions more multiplied!

plied: it is therefore essential to the animal matters to be more putrescible than the vegetable.

4. As whatever belongs to putrefaction presents a great interest to the science and to its numerous applications, the history of this alteration requires to be exhibited with a method sufficiently strict to omit nothing essential, to place every fact, every truth in the suitable light, to give to each the evidence and the force which belong to it, and to form of all a collective whole: I shall therefore treat successively and in a series of numbers;

A. Of the preliminary conditions of putrefaction;

B. Of the general phenomena which accompany it;

C. Of the existence of particular phenomena which may serve to characterize each animal matter;

D. Of the influence which the different media have upon it;

E. Of the different products to which it gives rise;

F. Of the last residuum which it leaves;

G. Of the causes which determine it; of its nature, and of the principles in which it consists;

H. Of its effects upon the living animals;

I. Of the means of remedying it;

K. Of those of preventing it;

L. Of those of stopping it, or of the antiseptics;

M. Of

M. Of the principal applications which all these facts offer to medicine ;

N. Of the products which men have derived from it for their wants.

Each of these subjects requires only a mere sketch, as the present object is only to connect them with what has hitherto been set forth concerning the general characters of the animal matters, to derive from them a general notion concerning their chemical properties ; and as besides the generalities, new details will be given in the history of each animal matter in particular.

5. Though the absence of life has already been announced at least as a condition essential to putrefaction, as the energy and the power of the vital principle actually opposes this motion its existence is admitted only when this energy is weakened, and in some particular cases.

Death is not the only condition necessary to putrefaction ; there is also required the combination of several other circumstances without which it would not take place. These may be reduced to moisture and moderate heat. It is proved by a great number of facts that the dry animal matters do not putrefy ; the bones, dried meat, and anatomical preparations keep without alteration ; bones softened by water, the soft flesh, and especially the animal liquids, pass on the contrary rapidly into putrefaction : it even principally follows the proportion of the quantity of water which exists in the animal substances.

substances. It is no less ascertained that there can be no putrescence at the freezing temperature and below it; but that the septic alteration commences at six or eight degrees above it; and proceeds in a progression the more rapid, as the temperature of the substances which experience it is more elevated. This condition, however, has its limits; heat near the temperature of ebullition, and even that which exceeds from 45 to 50 degrees of Reaumur's scale, no more permits putrefaction than the cold; it even defends the animal substances against this motion, as it tends, either to dry them, or to condense their texture or coagulate their mass, or to decompose them in another manner. The proportion of the elements which here act as conditions of putrefaction produce some modifications in it; water accelerates it by its quantity; the abundance of caloric sometimes joins the effects of partial volatilization with those of the putrid decomposition. It was long believed that the contact of the air was necessary to putrefaction; but it is certain that as it takes place in a vacuum, and in small proportions of air not renovated, the contact of the latter is only a condition which accelerates the putrescence, not by the influence which it exerts of itself upon the animal substances, but merely by serving as a recipient for dissolving and carrying off the materials that raise themselves in vapour. It is to the same class that we must refer the diminution of pressure, which some authors have considered as one

of the causes of putrefaction : we ought not to omit amongst the conditions of putrefaction the admixture of fermented matters, and especially of those that are putrefied with the fresh substances : this ferment acts by raising the mass, and accelerates and develops the putrefactive motion.

6. When the conditions of putrefaction, namely, an animal substance deprived of life, moist and exposed to a temperature above 10 degrees, are combined, this motion establishes itself ; the animal substance softens if it was solid, or becomes thinner if liquid ; its colour changes, and inclines more or less towards the red-brown, or the dark-green ; its odour is altered, and after having been at first faint and disagreeable, it becomes fetid and insupportable. An ammoniacal smell soon mixes with the first, and deprives it of part of its fetidity : this is only temporary, whilst the putrid odour existing before it, still remains after it and subsists during all the phases of the putrefaction. The liquids become turbid and filled with flakes ; the soft parts are melted into a kind of jelly or putrilage ; there is observed a slow motion, a slight inflation which raises the mass, and which proceeds from bubbles of elastic fluids, disengaged slowly and in small quantities at a time. Besides the general softening there runs out a serosity of different colour which constantly augments ; gradually the whole mass melts, this slight inflation ceases ; the matter sinks, the colour grows  
er ; at length the smell becomes frequently  
as



as it were aromatic and approaches even to that which is termed *ambrosiacal* ; finally the animal substance diminishes in mass, its elements evaporate and dissolve, and there remains nothing more than a sort of fat, viscous earth, still fetid.

The duration of this putrid decomposition, though varied, presents four very distinct periods which Boissieu has carefully distinguished : the first, or that of the *tendency* to putrefaction, exhibits an alteration that is still but slight ; it presents only the musty smell, the softening of the substance and a slight change of colour ; the second, or the *commencing* putrefaction, sometimes affords signs of acidity : the softening is more considerable ; the serosity begins to escape from the relaxed fibres ; the colour is more altered and the fetid odour already putrid. In the third degree of the *advanced* putrefaction, the odour which is always fetid, is more or less ammoniacal ; the matter dissolved into putrilage is of a dark colour ; it has lost much of its weight by the disengagement of a large quantity of volatile principles. The last degree, or the *accomplished* putrefaction, no longer presents the ammoniacal odour ; the fetidity is supportable, slight or none at all ; an aromatic odour frequently succeeds in the place of it ; the animal matter has lost a great part of its volume and all appearance of organization ; there remains nothing more than an earthy residuum, of a  
3 blackish-

blackish-brown colour, fat to the feel, which in this state is called *animal mould*.

7. These phenomena vary according to the different animal matters ; the difference of their nature and the different proportion of their principles are the source of them. It may even be said that each animal substance has its different manner of comporting itself in putrefying. Hence, all the varied and diversified scenes, which have been described by different authors, and of which we find a faithful account, both in the singular work of the physician Garman, entitled *De miraculis mortuorum*, in which are detailed the slow and successive changes of all the parts of the human body in the cemeteries, and in the *Essay on putrefaction* by Madame Darconville. But as this object belongs to the history of each animal substance considered in particular, I mention it here only in order to establish the principle of this variability of phenomena ; it shall be treated of in each of the subsequent articles.

8. It is also a variation independent of the animal matter, and subjected only to that of the surrounding bodies, which I must here consider in general under the title of the influence of the media in putrefaction. The single observation drawn from the different customs of nations with respect to their dead, or from the position of the carcases of animals placed in different circumstances, according to the places in which they are deprived of life, sufficiently  
proves

proves this remarkable variation. The bodies are seen altered in a different manner amongst the nations of the South Sea, who expose their dead in the air, upon elevated places, in the cabins of boughs of trees of their morais, upon the summits of trees; amongst the nations who immerse them in the water; and amongst the more polished nations who immerse them in the earth. I have said elsewhere that the animal parts placed in water are converted there into fatty substance; an alteration nearly similar takes place in moist earth: but the greatest difference which is of importance to be considered here, is that which takes place in the air, relatively to the phenomena which accompany putrefaction in close vessels. I have supposed this latter circumstance in describing (No. 6) the general phenomena of the putrid alteration. In the air, a portion of the entire animal substance is carried away and dissolved by the atmosphere; the products which are volatilized are equally carried away and dissolved by the air. The total and complete destruction of the animal substance is effected with more or less rapidity. All the events of this decomposition are much nearer to one another, as the exterior agents contribute to separate the elements of the matters which putrefy. Here the animal matter at last completely disappears, since after what the air receives of volatile principles, the small quantity of earthy residuum which escapes this aëriform solution penetrates gradually

gradually into the earth, where it is buried and carried away by the filtration of the waters.

9. Though we may rank amongst the phenomena of putrefaction, the matters which are disengaged from the putrescent animal substances, I shall consider them here in particular as products, because they proceed from the action of this motion itself, and because it is important to know them with more accuracy and precision than the mere inspection or even observation of these phenomena would permit. In order to determine the nature of these phenomena, to follow with attention the series and the epochs of their disengagement, and consequently to know in what the decomposition of the animal matter consists, it was necessary that a consecutive analysis of the putrid vapours, an attentive examination of the putrefied matters, should supply the place of the theory which had attempted to divine their characters. Thus it was long believed that the ammonia or volatile alkali was the sole product of putrefaction, and it was on this account that it had been called *alkaline fermentation*, in opposition to that which gives rise to the acetous acid: but though ammonia is indeed one of the principal products of this spontaneous motion, it is not the only one; there are others, the production of which precedes, accompanies, or follows its production, and which deserve to be known and studied with equal attention. There are even some  
animal

animal matters the septic decomposition of which commences with an acidification.

We should have only an imperfect and superficial notion of these products, if, after being assured that they are not the same nor in the same proportions with the different animal matters, we did not endeavour to approximate all these various products, to collect under a single point of view all the substances afforded in the putrefaction of the different animal compounds, and thereby embrace the totality of these products.

It is then found that the animal substance successively gives rise, in its putrid decomposition, to carbonated, sulphurated, and phosphorated hydrogen gases, which carry and propagate its infection far and wide; to water, which is disengaged in vapour, to ammonia, and to carbonic acid gas. All these bodies escape, are dissipated and volatilized; they carry off with them combined two and two together, the principal primitive materials of the animal compound. Other products, formed at various periods, as accessory circumstances of the composition of each animal matter, differ from the preceding by their fixity, and remain in this matter more or less solid and fixed: such are the zoonic acid, a fat matter, a kind of soap formed by this fat and ammonia; such is also the nitric acid, frequently formed in this decomposition, and fixed by an earthy or alkaline base; such finally is the unctuous mould which remains after the separation

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tion and the disengagement of the preceding products. Thus the animal matter is gradually separated, divided and destroyed: we shall soon see how these products are formed and succeed each other.

10. It is especially useful to distinguish, amongst the products of the putrefactive motion, that which is its last result, that which, after the disengagement of all the volatile materials, remains fixed, and constitutes the residuum. Its small quantity, its contracted volume, its earthy form very remote from organization, of which it presents nothing more than the wrecks or the most solid matter, have at all times fixed the attention of the philosopher. The remains of a large mass of organized matters, of which it forms only some hundredth parts, it has long been considered as a particular earth, which was distinguished by the name of animal earth. But this denomination, derived from its pulverulent state, its insipidity, its inodorous quality, as well as its fixity and insolubility, is inaccurate and erroneous, since this residuum, this animal mould, contains, besides the acids and the earths combined in the saline state, a portion of fat coaly matter, which, when distilled, still yields oil, carbonate of ammonia, and leaves a coal charged with earthy phosphates. The fixed, saline, earthy and metallic matters which constitute the nature of this residuum, retain for a long time a portion of oily substance more or less concrete, which is destroyed only very slowly; and

and in order that they may be reduced to the pure saline and earthy state, analogous to the ashes which remain after combustion, it almost always requires a long series of years. Thus carcases buried in the earth are not reduced to their dry skeleton, and do not lose the last remains of their soft parts, till after a lapse of time, which generally exceeds seven years, and which is sometimes prolonged to more than thirty. The excavations in the ground of the cimiterie of the Innocents at Paris have proved this to me in an incontestible manner; it is easily conceived that the proportion and the nature of this residuum correspond entirely with those of the fixed matters, which formed constituent parts of the animal compounds, and that they must vary according to each of these compounds.

11. As we have now seen the conditions of putrefaction, the phenomena which it presents to the observer, the general influence which it receives from the mediums in which it acts, the different products which it affords, and the residuum which it leaves, it is time to occupy ourselves with its intimate nature. It is not enough to have considered it as a slow decomposition, as a spontaneous analysis, as a destructive fermentation of the organic compounds, because it has all the characters of the intestine motions which are designated by this name in chemistry; it is necessary that we should penetrate more intimately into its cause, to ascertain and explain its mechanism. It is evident that it consists in

a change effected by a sum of attractive forces superior to those which keep the principles of the putrescent substance united. These principles are, as we know, hydrogen, azote, carbon and oxygen, with which are frequently associated sulphur, phosphorus, and different kinds of phosphates.

It is evident that, in putrefaction, part of the hydrogen unites with the azote to form ammonia; another part of the hydrogen combines with a portion of oxygen with which it constitutes water; that a certain quantity of carbon, combined with a relative quantity of oxygen, gives rise to carbonic acid; that a portion of azote united with a third quantity of oxygen produces nitric acid; that a combination of hydrogen, carbon and azote forms the volatile or the fixed oil, according to the proportion of these principles; that another combination between the same matters and oxygen composes the zoonic acid; and that finally, the saline, earthy, and metallic substances, being unalterable, or little alterable by the intestine motion of putrefaction, remain untouched and passive in the last residue of this spontaneous motion, carried to its *maximum*.

It is no less evident that these matters or new compounds, which did not exist originally in the animal substances, unite two and two together, the ammonia and the carbonic acid, the ammonia and the zoonic acid, the ammonia and the oil which it reduces to the saponaceous state.



state, and are disengaged in this form in the air, or dissolved in the water. All these new compositions, which are less complex than the primitive compound which gives rise to them, and which are the products of its slow dissolution and the indications of its destruction, are the consequence of numerous attractions which act amongst the multiplied principles of the organic compound deprived of life.

We may comprehend in a general formula the totality of all these attractions, and express with precision what takes place in putrefaction, by saying that the sum of the forces which tend to unite the hydrogen with the azote, the oxygen with the carbon, the carbonic acid with the ammonia to form the ammoniacal carbonate, and the hydrogen, the carbon, and the oxygen to produce oil; this latter with the ammonia to constitute a soap; and finally, the hydrogen with the oxygen to produce water, and the latter with all the preceding compounds,—that this whole sum is superior to the sum of the forces which retain in quaternary combination the hydrogen, the azote, the carbon and the oxygen, to constitute the animal compound.

We have here represented only the alterant action of these forces, and the putrefactive effect which results from them in close vessels, into which nothing extraneous to the organic substance can enter, and from which nothing can escape; for though the results are ultimately identic, they take place in a very different

manner in the midst of the atmospheric air. In the latter circumstance, a part of the animal substance is dissolved and carried off conjointly and separately by the air and by the water; the ammonia and the carbonic acid are volatilized as fast as they are formed; a portion of carbonated hydrogen is volatilized by the alteration of temperature: and there is formed neither fat matter nor ammoniacal soap.

Thus may be explained in a simple manner the phenomena and the products of putrefaction; and thus its conditions, its varieties, its duration, &c. may be comprehended. It was natural to consider them as inexplicable, as long as the nature of its products, that of the water, of the ammonia, of the oils, and of the acids, were involved in an obscurity which necessarily extended itself over the progress and the mechanism of this kind of fermentation. This obscurity has, as we see, been dispelled by the efforts of the pneumatic chemistry which has left nothing unintelligible in the knowledge of this spontaneous decomposition. This is one of the fruits which we owe to its progress and its happy revolution.

12. Amongst the phenomena dependant upon putrefaction which it is of importance to consider, must be reckoned the dangerous effects which it produces upon living animals. If we except a very small number, belonging to the last classes of these beings and endowed with the least sensibility, there are none which an animal matter in the state of putrefaction does not deter  
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and repel from the place where this scene of death and destruction is exhibited. By the disgust with which it inspires them, by the hasty flight which it occasions, it is easily conceived that this phenomenon is inimical to life, and that it threatens it with remarkable energy. Accordingly, the greater number of animals cannot feed upon animal matters putrefied to a certain degree; and though some of them, being indolent and ferocious at the same time, devour carcases already tainted, none make them their food when the putrescence is too far advanced. We know the aversion and disgust which all mankind have against corrupted animal matters, the disagreeable effect which they produce upon their organs, and the repugnance which their sense of sight and smell experience at the mere aspect of these matters. Frequently the putrid miasmata or the gases which are exhaled from bodies in the state of putrefaction, are so deleterious, that men and animals are deprived of sense by their contact. When they do not produce this sudden effect, they occasion putrid diseases in such as are exposed to them. Some individuals contract external affections, carbuncles, malignant and gangrenous pustules by the corruptive action of these vapours; others are influenced by them in a much more dangerous manner, for besides a considerable prostration of the powers of life, they become affected with putrid fevers of the most malignant character. It is not yet known what is the nature of the  
putrid

putrid gas from which these terrible effects arise : it is not the azotic gas, as some modern physicians have thought, who on that account have given it the name of *septon* or rather *septic gas*. There is reason to suspect that they ought rather to be attributed to the action of the putrefied animal matter itself, which being dissolved in the gases exhaled during its putrefaction, carries into the organs which are the focus of life its benumbing or debilitating principle, and pours into the torrent of the animal humors the putrid germe or ferment, which they are unfortunately so much disposed to receive.

13. Science, whilst it enables us to ascertain the source and the cause of these terrible effects, furnishes us with arms for preventing or determining its influence. Two means present themselves, suggested by reason and confirmed by experience : the one, which belongs to the police and the wisdom of government, consists in removing from populous places, particularly from large towns where the accumulation and crowded situation of the inhabitants is already a pre-disposing cause of putrid diseases, the sources of infection and putrefaction. To aërate the habitations, to establish a frequent ventilation in them, to cover the common sewers, to remove sinks of all kinds, to establish burial places out of the towns, to kindle large wood-fires in such situations that the wind may carry the smoke into the places which we wish to preserve, to obtain a profusion

sion of fresh and running water in open canals, and especially to cause it to ascend in fountains or precipitate itself in cascades; these are the grand means of preventing putrefaction or at least of repelling its invasions. The other means, more confined in its application, and practicable only in small spaces or in circumscribed places, has for its object to destroy the putrid miasmata themselves, to fetter their activity, and to neutralize their virulence. This effect is obtained by the disengagement of the muriatic acid in gas, and especially by the oxygenated muriatic acid, which I consider, and which I proposed some years ago, as the greatest external antiseptic, because it attacks and destroys the animal combination which constitutes the virus. Its advantages and use in this point of view will be the better understood, in proportion as the principles of chemistry shall be diffused in the work-shops and become familiar to manufacturers and artists.

14. Art has always sought the means of preventing the putrefaction of animal matters, and defending them against corruption. The number of means and matters of this kind which it has discovered is very considerable; the principal are, as is easily conceived, all the processes which destroy the conditions that give rise to it. Thus the desiccation of animal matters, the privation of water, refrigeration, or pressure, are the first and most certain, because by their simple influence, they make the  
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the causes disappear which develop putrefaction. Many substances with which the animal matters are enveloped or which penetrate their texture answer the same purpose. The acids, the salts, the aromatics, sugar, the fixed and volatile oils, the resins, camphor, the powder of dry and odorous plants, of acrid resinous bitter woods; charcoal, generous wines, alcohol; the bitumens; particularly possess this property; accordingly, these are the substances which are employed with the most security for preserving animal matters in the art of embalming, salting, in condiments, macerations in vinegar, &c.

15 Medicine has been occupied with a particular interest in the research of substances capable of retarding or stopping the progress of putrefaction which frequently manifests itself in some parts of the diseased human body; it has called them *antiputrescents* or *antiseptics*. On comparing them with those already indicated we find great analogies between them.

Godart observes that all the possible antiseptics may be reduced to three classes:

*A.* The refrigerants, which comprehend all the means of diminishing heat, the great influence of which upon putrefaction we already know. He ranks in this class: cold, the aqueous substances, the farinaceous matters, the acids, and the sedative.

*B.* The ventilants or those which dissipate  
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the putrid miasmata, are the agitation of the air, the evacuents, the cordials ;

C. The corroborants, which condense or contract ; amongst which he enumerates the acerb, the astringent, and the bitter substances.

Bordenave has referred the medicinal antiseptics to six classes ; namely, the antirelaxants, the stimulants, the astringents, the balsamics, the desiccants and the caustics.

Bossieux, in a very extensive and very methodical table, has presented their series distributed into a great number of ingenious divisions, which it is not my object here to exhibit. In all the considerations relative to these agents, there have especially been distinguished the sulphuric acid, the carbonic acid, the vegetable acids, the Peruvian bark, Scordium, Guaiacum-wood, camphor, tannin, the gall-nut, alcohol, the metallic salts and their solutions : some have even gone so far as to pretend to restore flesh already in a very advanced state of putrefaction to its original condition. Macbride has more especially attributed this effect to carbonic acid, because putrified flesh immersed in it resumes a part of its colour and consistence : but it is very evident that this is an exaggerated pretension, and that nothing more has been effected than the separation of the exterior part, the most advanced in putrefaction, from the still sound portion ; for science teaches us that it is impossible to form anew an animal matter that has been destroyed, and that we cannot in  
this

this respect surpasses Nature, who herself is subjected to the impossibility of making a retrograde step in this putrefaction.

16. After all the preceding considerations, it cannot be doubted that putrefaction is a slow decomposition, a kind of spontaneous analysis effected by virtue of complicated attractions, existing between the numerous principles of the animal matters, namely, the hydrogen, the azote, the carbon, the oxygen, the sulphur, and the phosphorus ; that the motion, which is excited amongst these principles, and which has great analogy with a fermentation, (whatever Boerhaave and his school may say of it, who did not admit of this analogy) is in some measure ordained or willed by Nature ; that it is the means which she employs in order to destroy the animal organization and composition, when the animal matters, deprived of life, can no longer serve in the animated form, for the exercise and support of which those primitive matters had only been lent them according to the immutable laws established in the order of the universe ; that Nature thus takes back those principles, which are no longer employed in the phenomena of life, and restores to other more simple combinations the portion of matter which constituted the bodies of the animals. Thus, by the admirable order which exists in the economy of Nature, the most complicated phenomena which represent during life the master-piece of organization the most numerous chemical phenomena, are



are reduced after death into more simple compounds, almost all binary,—and by the aid of the putrid decomposition, return into the class of the minerals, are thus reduced almost to the state of elements, are dissolved in the water, diffused in the earth, and serve for new combinations. Thus in studying the properties and chemical characters of animal substances, we are led back to the simple and primitive substances with which we commenced the study of the natural substances. This effect, this transition, this circulation of substances, which had long ago been discerned by the ingenious Becher, were called by this chemist the circle of the eternal motion, *circulus æterni motus*.

17. Men have at all times availed themselves of the phenomena and products of putrefaction, and have in some sort derived the support of their existence from the very womb of death and destruction. The animal matters corrupted and reduced to the state of mould are employed with much advantage as manures; in order to diminish their too hot and too nourishing properties, they are not distributed in the ground which is intended to be manured, until they are almost entirely destroyed. They are sometimes also prepared by particular processes of desiccation and concentration, as is done in the vicinity of Paris with the filth of the privies, in order to convert it into a dry and very fecundating powder, which is called *poudrette*. In other places, by causing the animal matter to putrefy with vegetable

vegetable substances, or by moistening the latter, deposited in dry layers and exposed to decomposition under sheds with animal liquids, urine, the waters of kitchens, of shambles, &c. the production of nitre is accelerated, by means of the azote which those liquids afford. In some manufactories animal substances, and especially corrupted urine is employed for extracting with facility very abundant quantities of carbonate of ammonia. Lastly, we might avail ourselves of the discovery which I have made of the conversion of the bodies of animals into fat in stagnant waters or in moist earth, in order to prepare with offals that hitherto have been applied to no use, fats which would be useful in a great number of the arts. We are even assured that English industry has already availed itself of this discovery, and that a concrete oil is prepared in England by this mode of putrefaction.

18. There are some circumstances which, by opposing more or less powerfully the putrid decomposition of the animal matters, leave them only the possibility of being converted into substances of a different nature, and susceptible of keeping for a long time in this state. In this class are to be ranked ; 1. dead bodies desiccated by a dry and glowing atmosphere, or by an arid and violently heated sand ; 2. the natural mummies, and the mummies which art, at the suggestion of a religious sentiment, or of a respectful attachment to the remains of beloved objects, prepares

prepares by the aid of all the preservative means and embalmment; 3. bodies and their organs prepared by different anatomical means; 4. hair, silk, feathers, skins, prepared and preserved in solid and durable textures; 5. smoked, salted flesh, which has become hard and as it were of a woody consistence, in which state it keeps for a long time without alteration; 6. bones, horn, scales, dried and converted into utensils or machines of various forms and various utility; 7. bones impregnated with different minerals in the bosom of the earth, and especially those which are converted into turquoise. There is also reason to believe that a portion of the remains of animal substances, so abundant in the water of the sea, and of large rivers, enters by their more or less advanced decomposition, and by assuming the character of oily matter, into the formation of the bitumens. As to the petrified animal substances, which are generally ranked in the same series with the preceding substances, these are either solids impregnated with calcareous disposition, or merely moulds filled with siliceous matter.

## THIRD ORDER OF FACTS

OF THE PROPERTIES OF PARTICULAR  
ANIMAL SUBSTANCES.

## ARTICLE I.

*Of the Comparison and the Classification of  
the different Animal Substances.*

## SECTION I.

*Of the different Modes of their Classification.*

1. IT is not sufficient to have considered the animal substances in general, and investigated the characters which distinguish them from the vegetable matters. This first inquiry ought only to be considered as an introduction to the history of these substances in particular. It ought to precede and to elucidate it; but it cannot be substituted in place of it; it has only the advantage of rendering more intelligible the examination of their properties, and diminishing the extent of the details which this examination would have required, if the exposition of the general properties of the animal matters had not determined their nature.

2. Though it may appear, at the first glance, a matter of indifference whether the chemical  
4 history

history of the animal matters be treated in such or such an order, it is however necessary to decide in the choice of this order, and on this account it becomes necessary to indicate and compare with each other the different methods of classifying these substances. We know in the first place that they may be considered as a kind of immediate materials of animals, and that in this point of view it would be possible to divide or rather distribute them, as has been done with respect to these vegetable matters, into such as are soluble in water, into oily, saline, solid and insoluble substances. But this first kind of division is very imperfect and very inaccurate, as it is far from comprehending all the substances which compose the bodies of animals.

3. The division of these substances into liquids and solids is also insufficient. Frequently the works on chemistry have followed the division into recrementitious liquids, such as the blood, the lymph; excrementitious, such as the urine, &c. and excremento-recrementitious, as the bile, the sperm, &c. We have no greater reason to be satisfied with this classification, which presents nothing well fixed and accurate. These matters might be arranged, according to their chemical nature, into four classes, according to the superabundance of one or other of the principles which enter into their composition. Thus we should have:

*A. Hydrogenated or oily animal substances; such as the fat, the cerumen, the bile.*

*B. Oxygenated*

*B. Origenated* animal substances or oxides; the albumen, the lymph; in these would be comprehended the lymph, the water of the interior cavities, the cerebral pulp.

*C. Carbonated* animal substances; the gelatinous or mucous, comprehending the membranes, the aponeuroses, the tendons.

*D. The azotated* animal substances, fibrous or fleshy; such as the muscles, certain visceral parenchymata.

*E. The acid* animal substances; the uric acid, the formic acid, the boric, &c.

*F. The saline* aqueous animal substances; as the aqueous and the vitreous humor, the tears, the saliva.

*G. The phosphated* animal substances, especially those in which the phosphate of lime predominates; in this class would be placed the nails, the horns, the hair, the bones.

*H. Finally, the mixed* animal substances, containing several of the preceding materials; this last class would belong to the blood, the milk, the sperm, the urine.

4. The chemical method which I have just sketched would be beyond all contradiction the most perfect, the most exact, and that which ought to be preferred to all others, if the animal analysis were more advanced, and if the comparative nature of the animal liquids and solids were better known. For not to mention that all these matters have not yet been sufficiently analyzed to enable us to rank them in one or other of the eight classes

classes that have been indicated, I cannot present this division into eight classes, except as a very imperfect attempt, which, though not purely hypothetical, is not sufficiently well founded upon experience for it to be adopted and considered as proper to afford a right notion of the comparative nature of the different animal compounds. I give it here rather in order to show what chemistry may hope to attain in this respect, than as a true method of classification. Accordingly, I shall not adopt this method in the following articles, because not yet sufficiently exact.

5. The following is the order which the actual state of chemistry and of animal physics permits me at present to adopt. I shall divide the animal substances into three classes: in the first I shall rank those which are generally diffused throughout the whole body of animals; in the second, those which belong to some particular region or organ, and in the third those which are found only in some orders of animals, whilst the subjects of the two first are found generally in all. The animal matters generally diffused are either liquid, such as the blood, the lymph, the fat, the transpiration, the humor of the interior cavities of the synovia; or soft, as the cellular texture, the membranes, the tendons, the aponeuroses, the ligaments, the glandular texture, the muscles, the skin and the epidermis; or solid, as the horny texture of the hair, the cartilaginous texture, the osseous texture.

6. The second class of animal matters, belonging to the different regions of the bodies of animals, comprehends in four divisions :

*A.* The substances contained in the cranium.

*B.* Those which the cavities of the face present.

*C.* Those which are found in the thorax.

*D.* Those inclosed in the abdomen.

The matters belonging to the cranium are the cerebral pulp, the nervous fluid, the liquor of the ventricles of the brain, the pineal concretions.

Those of the face are the aqueous humour of the eye, the vitreous humour, the crystalline humour, the tears, the nasal mucus, the mucus of the mouth, the mucus of the tonsils, the saliva, the salivary calculi, the tartar of the teeth, the cerumen.

To the matters belonging to the thorax are to be referred the tracheal and bronchial mucus, the gas proceeding from the lungs, the pulmonary concretions and the milk.

The substances contained in the abdomen comprehend the gastric juice, the pancreatic juice, the bile and the biliary calculi, the intestinal juice, the chyle, the excrements, the intestinal gases and the concretions of the intestines, to which are to be added the liquor of the amnios, the superrenal liquor, the meconium, liquids peculiar to the foetus, and finally, the urine, the urinary calculi, the juice of the prostata, and the sperm.

7. The



7. The third class of animal matters comprehends those which are peculiar to some orders of animals, and which are frequently employed in the arts; and as these orders are seven in number, it is divided in the same manner.

The first division contains those which are particularly furnished by the mammalia, such as ivory, hart's horn, horn, wool, musk, civet, ambergrease and the bezoars.

The second division is reserved for those which are obtained from the birds; namely, the eggs, the feathers, the dung, and the membrane of the stomach.

The third presents the product particular to the amphibia, the viper and its poison, the skink, the lizard, the toad, the tortoise and its shell.

The fourth is appropriated to some productions peculiar to fishes, ising-glass, fish-oil, the scales of the blay, and the bones of the head of several of these animals.

To the fifth I refer some matters belonging to the testaceous fish; the bones and the ink of the cuttle fish, pearl and mother of pearl shells.

In the sixth I place those which are extracted from insects and worms, the honey and the wax of bees, cantharides, wood-lice, ants, their acid and lac, the bread of the ant, silk, cochineal, kermes, crab's eyes, the lumbrici.

Finally, the order of Zoophytes affords four particular animal matters; namely, coralline, coral, the madrepore, and the sponge.



# ANIMAL SUBSTANCES.

T65

Soft parts.	{	Cellular texture,	-	7
		Membranous texture,		8
		Tendinous texture,	-	9
		Aponeurotic texture,		10
		Ligamentous texture,		11
		Glandular texture,	-	12
		Muscular texture,	-	13
		Cutaneous texture,	-	14
		Epidermoid texture,	-	15
Solids.	{	Hair,	- - -	16
		Cartilage,	- - -	17
		Bone,	- - -	18

## SECOND CLASS.

*Animal Matters belonging to some particular Regions of the Body of Animals.*

To the cranium.	{	Cerebral pulp,	-	19
		Nervous fluid,	-	20
		Liquor of the ventricles,		21
		Pineal concretions,		22
To the face.	{	Aqueous humor,	-	23
		Vitreous humor,	-	24
		Crystalline humor,	-	25
		Tears,	- - -	26
		Nasal Mucus,	- -	27
		Mucus of the Mouth,		28
		Mucus of the tonsils,		29
		Saliva,	- - -	30
		Salivary calculi,	-	31
		Tartar of the Teeth,		32
		Cerumen,	- -	33

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8. In order to exhibit the collective whole of this division of the animal substances, I here present a table in which the relation, the difference and the classification will appear at the first glance. It will there be seen that there are fifty-three different substances in the two first classes, and forty-one in the third; the importance of the fifty-three first obliges me to treat of them in a pretty considerable number of separate articles. As to those of the third which present more or less resemblance to those of the two first classes, I shall content myself with giving an account of them in seven articles which will comprehend the particular products formed by the seven of animals.

## TABLE

Containing the Division and the Classification of the Animal Matters.

All the Animal Matters, considered in their mutual relations, may be divided into the three following Classes.

## FIRST CLASS

Animal Matters belonging to the first class.

To the thorax.	Tracheal and bronchial	
	mucus,	34
	Gas of the lungs,	35
	Pulmonary concretions,	36
	Milk,	37
To the abdo- men.	Gastric juice,	38
	Pancreatic juice,	39
	Bile,	40
	Biliary calculi,	41
	Intestinal juice,	42
	Chyle,	43
	Excrements,	44
	Gas of the intestines,	45
	Intestinal concretions,	46
	Liquor of the amnios,	47
	Superrenal liquor,	48
	Meconium,	49
	Urine,	50
	Urinary calculi,	51
	Juice of the prostata,	52
	Sperm,	53

## THIRD CLASS.

*Animal Matters belonging to each of the Seven Orders of Animals in particular.*

To the mam- malia.	{	Ivory,	-	-	-	54
		Hartshorn,	-	-	-	55
		Horn,	-	-	-	56
		Wool,	-	-	-	57
		Musk,	-	-	-	58
		Civet,	-	-	-	59
		Castor,	-	-	-	60
		Ambergris,	-	-	-	61
		Spermaceti,	-	-	-	62
		Benzoar,	-	-	-	63
To the birds.	{	Eggs,	-	-	-	64
		Feathers,	-	-	-	65
		Dung,	-	-	-	66
		Membrane of the Stomach,	-	-	-	67
To the am- phibia.	{	Viper,	-	-	-	68
		Toad,	-	-	-	69
		Skink,	-	-	-	70
		Lizard,	-	-	-	71
		Tortoise,	-	-	-	72
To the fishes.	{	Isinglass,	-	-	-	73
		Fish-oil,	-	-	-	74
		Fish-scales,	-	-	-	75
		Fish-bones,	-	-	-	76

To

To the tef- tacea.	{ Bones and ink of the cuttle-			
	fish,	-	-	77
	Pearl and mother of pearl,			78
	Shells,	-	-	79
To the insects and worms.	Honey and wax,	-		80
	Cantharides,	-	-	81
	Wood-lice,	-	-	82
	Ants,	-	-	83
	Lack,	-	-	84
	Ant-bread,	-		85
	Silk,	-	-	86
	Cochineal,	-	-	87
	Kermes,	-	-	88
To the zoo- phytes.	Crabs'-eyes,	-	-	89
	Lumbrici,	-	-	90
	Coralline,	-	-	91
	Coral,	-	-	92
	Madrepores,	-	-	93
	Sponges,	-	-	94

## ARTICLE II.

*Of the Blood.*

## SECTION I.

*History and Analysis of the Blood.*

1. THE blood, this red and hot fluid contained in the arteries and the veins, necessary to life, moved incessantly by the circulation, moistening all the organs, conveying into them heat and motion, distributing nourishment, acting an important part in the animal economy, has always been considered as the principal object of the studies and the researches of the anatomist, the physiologist, and the physician. The subject of many important inquiries, of a multitude of experiments, it is still, notwithstanding the studies of the philosophers and the numerous observations of the physicians, an inexplicable enigma; and though more advanced in the knowledge of its properties, modern physics are very far from the point at which they must arrive in order to explain its real influence upon the phenomena of life. Its effects appear to be extremely complicated, its uses multiplied ad infinitum; we see it preside in some measure over all the functions; respiration  
tion



tion acts especially upon it; the circulation is performed in order to convey it to all parts of the body; it is this which warms the whole animal system; it causes the heart to move; it is the common source of all the secretions; it nourishes all the organs; it affords the recrement as well as the excrement; it repairs the waste of all the parts; the lymph is one of its productions; the transpiration escapes from the cutaneous extremities of the canals which transmit it; it exists every where, it vivifies all the organic systems, the totality of which constitutes the animal machine; it must therefore offer to the philosopher the series of all the problems presented to him by the animal economy.

2. Accordingly the number of learned men who have occupied themselves with it is immense: some have examined its chemical properties; its mere quantity, its weight, its motion have been the object of much investigation, which is not even yet entirely terminated. Even its proportion is not known; and authors have varied amongst themselves from eight pounds to twenty-eight pounds for the quantity contained in the body of a man of the middle size. Some have said that it forms a fifth of the weight of the body, others only a twentieth. Some reckon it at a sixteenth, a fifteenth, &c. It is commonly believed to be distributed in such a manner that the veins contain nine and the arteries four parts. When we read in the learned work on physiology by Haller, the opinions of

of Harvey, Allen, King, Lister, Drelincourt, Hales, Moor, Siegel, Primerose, Kiel, Lobb, Lower, Quesnay, F. Hoffmann, upon the proportion of the blood in the human body, we see how many difficulties and uncertainties attend the precise knowledge of its most simple properties. If we also remark in the same author what diversity of opinion has prevailed in the schools concerning the difference of colour and temperature of the arterial and the venous blood, a question which nevertheless seems easy to be solved by mere inspection or by simple experiments; if we compare the celebrated names of Galen, Erasistratus, Aretaeus, Harvey, Lower, Mayow, Schreiber, Willis, Swammerdam, Duvorney, Verheyen, Helvetius, Michelotti, Lancisi, Sévérini, Cheselden, Hamburger, Martine, Pitcairn, Jurin, De Haen, who have not been able to solve these problems with accuracy, and who have left the result uncertain, notwithstanding an assiduous labour of several ages: we shall be able to conceive with what fetters the human understanding has been shackled in its progress relative to this important part of physiology.

3. Hence, many able and learned physicians, deterred for a long time by this unsuccessfulness of the physical sciences, and not trusting more to the experiments of the chemists, have thought it necessary to take a different course in order to appreciate the properties of the blood. Founded upon the phenomena which it presents in the living animals, they have considered

sidered it as an assemblage of all the animal liquors, as a reservoir of all those materials, a solution of all the solid parts, a sort of liquid flesh, of plastic animal mucilage, hot, boiling, moved in torrents, tending to all parts of the body, communicating with all, assuming a particular nature in each organ and even in the vicinity of each of them, distributing into all their cells the materials which must serve for their reparation, remaining fluid only by the effect of motion, precipitating fibres already become solid by a slight agitation, disposed to assume the state of concrete mass when its motion is retarded, animated by a particular or vital power which disappears in death, and which can no longer be perceived in it when it is separated from the living animals. This series of notions they have called the medicinal analysis of the blood. But whatever ingenuity Bordeu has displayed in the exposition of these ideas, we find in them neither precision, nor accuracy, nor positive knowledge; but merely vague notions, the fruits of an active imagination, perhaps liable to the same reproach which he cast upon the chemists.

4. Notwithstanding the little confidence which the physicians (indeed amongst those who though otherwise possessed of much learning and talents had not acquired a sufficient stock of chemical knowledge) have testified for the examination of the blood by the means of this science, a great number of chemists, also belonging

ing to the class of the physicians, and consequently competent to balance the opinion of the first, have occupied themselves with the chemical analysis of the blood.

After the first still very inaccurate attempts of Barbatus and Bohnius in the seventeenth century, after the disputes of Vieussens, of Willis, &c. whether to admit or reject the presence of a pretended acid in the blood; Ruyfch treated experimentally the concrescibility of the blood, the art of obtaining from it fibres, textures, membranes; Lewenhock and Hartfoeker investigated its nature with the microscope, and described in it a compound globulous structure, of which Boerhaave has made an ingenious use, though it is nothing more than a sort of microscopic fiction.

Hales wrote learnedly upon its analysis by fire, and upon the elastic fluid disengaged from it by this agent.

Lemery found it to contain iron ready formed, the proportion of which was determined by Menghini.

Hoffmann was one of the first who described the chemical characters of its different parts separated spontaneously.

Langrish, Cheyne, Swencke, have given analyses of it that are almost complete for the time in which they wrote.

Gaubius examined it after Boerhaave with much greater accuracy than his predecessor.

Rouelle

Rouelle the younger first showed with precision the salts that are contained in it.

G. Hewson described several of its properties with sagacity.

Bucquet, immediately after Rouelle, particularly studied the chemical characters of the coagulum and of the fibrous part.

Dehaen has shown that its coagulation, its serum, its buffy coat, vary according to the circumstances of its extraction in venesection.

Cygnar did all in his power to discover the cause of its rutilation by the air, which has since been placed out of doubt by the experiments of Lavoisier, Menzies and Godwyn.

Crawford has determined the difference of the specific heat of the arterial and of the venous blood.

Citizens Deyeux and Parmentier have examined with much attention the different materials of the blood, the serum, the fibre, the coagulum, and some of its morbid alterations.

I have likewise occupied myself with it, at different times, during fifteen years past; I have ascertained the presence of the gelatin in it, the action of a violent fire in open vessels, its difference in the foetus, &c.

The rapid sketch which I have just presented is sufficient to prove that much labour has been bestowed upon the nature of the blood; I must terminate it by observing that though chemistry has not yet resolved all the problems which this fluid presents to it, it has at least shown the  
path

path that must be followed in order to find their solution, as the following details will prove.

## SECTION II.

### *Of the Entire Blood.*

1. THE blood of man, and that of the bullock which much resembles it, and which has been most frequently subjected to chemical analysis, as it is procured with great facility, is a liquid of a beautiful purple-red colour, of a consistence a little thick, gluey and viscous, soft and, as it were, saponaceous to the touch, of a particular faint odour, and of a sweetish and saline taste. Its temperature is between 29 and 32 degrees centigrade. Physiologists have differed from each other with respect to the specific gravity which they have attributed to it. They have found its relation to the gravity of water as 1053 or 1126 to 1000. It has been said that, when viewed with the microscope, it is a compound of red globules swimming in a transparent liquid, and that the red globules are formed of several other yellow globules united together; that these globules are divided and broken in the small vessels, and thus give rise to liquids more and more pale, less and less coloured, which are found in the orders of vessels more and more attenuated. These globules were described as capable  
of

of being compressed, elongated, flattening, and passing through the animal strainers. Modern physiologists have rejected all these ideas as chimerical. What is true, says Haller in the history of these globules, is that we actually see such in the blood with the aid of the microscope; but the yellow ones which are also sometimes seen in it are not smaller than the red, they are not divisions of them, they appear only in debilitated animals; they swim in a transparent and almost invisible serum; the red globules have neither been seen to break nor to re-unite, they are not converted into serum by their pretended division, of which in fact (as we shall see hereafter) they have neither the characters nor the intimate nature.

6. The entire blood, which we ought to examine before its particular parts, when exposed to a mild temperature and which does not exceed 100 degrees of the centigrade thermometer, diffuses but very little vapour in the air, thickens and coagulates, assumes a brown colour much resembling that of the liver of animals, and gradually dries if we agitate it, so as to be converted into an almost black powder, greasy to the touch, and which keeps without alteration in well closed vessels; in the air it becomes a little moist and covered with an efflorescence of carbonate of soda. The coagulum of the blood dried in the air becomes sensibly attractable by the magnet; heated more violently in a crucible, it softens, becomes as it were oily, melts,

melts, swells, inflames and is reduced into coal, after having exhaled a very fetid smell. What is disengaged during this strong and decomposing action of the open fire presents a series of products which I have carefully described; first, ammoniacal water; secondly, a white and very pungent vapour of carbonate of ammonia, and soon a yellowish thick smoke very fetid, which is manifestly oily and inflammable; afterwards Prussic acid recognizable by its smell of bitter almonds; then phosphoric acid, announced by some flames emitted from the coally and red-hot matter; finally, carbonate of soda. There remains in the crucible a mixture of oxide of iron of a blackish or brown-black colour, granulated and crystallized; of carbon combined with a little iron, and almost in the state of carburet of this metal; finally, of phosphate of lime and muriate of soda. We see that in this operation the constituent principles of the blood are separated almost all into binary compounds, if we except the oil and the Prussic acid. It is to be observed that when the blood is boiled in a basin of copper, this liquid dissolves enough of the metal to yield, on calcining it with alkali, cupreous Prussiate, even in abundance.

7. When instead of treating the blood by the fire in open vessels, we distil it in close apparatuses, with a mild heat, especially with that of the water bath, it affords much water, which has a faint smell, and putrefies and becomes fetid when kept; the blood at the same time



is found coagulated into a brown substance and even dried. If we afterwards distil it in a retort, by a well managed fire till the bottom of the retort of porcelain, in which this distillation ought to be performed, is red-hot, we obtain fetid water charged with carbonate and zoonate of ammonia, besides an ammoniacal soap which gives it a red-brown colour; an oil, at first red and light, afterwards brown, blackish, thick and almost concrete, very fetid, and which, before it condenses, fills the receivers with a thick white vapour of crystallized carbonate of ammonia; and lastly, carbonated and sulphurated hydrogen gases. There remains in the retort a spongy coal, of a brilliant and as it were metallic appearance,, adhering very strongly to the vessel, very difficult to be incinerated, in which are found by analysis, besides the carbon united with a little iron, phosphate, muriate, and carbonate of soda, phosphate of iron, and phosphate of lime. Though this distillation by a naked and violent fire, the only means of analysing the blood that was formerly possessed, does not afford the real principles of the blood as was formerly believed, it corresponds with what has already been indicated in the history of the general characters of animal substances, and like the treatment by the open fire, it shows us what are in general the primitive principles of the blood.

8. Blood, exposed to the air, after it has  
drawn out of its vessels, fixes or concretes  
more

more or less speedily ; it forms, either an almost solid mass, red without and black within, or a substance as it were gelatinous, tremulous, resembling currant-jelly, according to the age and the strength of the individuals from whom it is taken. It is this spontaneous coagulation which caused the ancients to adopt the notion of its plastic power, and to consider the blood as a kind of liquid flesh. Some hours after this spontaneous concretion into a single homogeneous mass, the blood shrinks, condenses, and there separates from it a liquid of a greenish white colour, which is called the serum of the blood. Though this double effect takes place in close vessels as well as in the air, the latter favours its production ; its mere contact converts the black colour of the coagulum into a brilliant red ; soon, and especially when the atmosphere exceeds twelve degrees or the temperate heat, the blood softens, melts, dissolves, exhales a smell, at first faint, afterwards fetid, and at last is completely decomposed by putrefying. The moisture of the atmosphere accelerates this putrefaction, whereas great dryness combined with a high elevation of temperature in the air, dries this liquid and thickens it, instead of giving rise to the septic decomposition like the preceding ; the contact of oxygen gas renders the colour of the blood brilliant ; azotic and hydrogen gas, on the contrary render it brown or violet ; sulphurated hydrogen gas blackens it.

9. The blood is entirely soluble in water when it is perfectly liquid ; when it is coagulated the water dissolves only its red part and leaves the fibrous, solid and white part of the coagulum insulated : this is the means which is put in practice in order to separate these two substances, and form the commencement of an analysis of the blood both immediate and simple. If we throw blood into water heated above 45 degrees of the centigrade thermometer, this liquid presents a number of floating pellicles or membranes ; we see this effect in blood-letting at the foot. Above the temperature here indicated in the water into which it is thrown, the blood is entirely coagulated into brown flakes which condense and shrink together. Long continued maceration of the blood in water favours its putrid decomposition, the colouring matter is precipitated and becomes darker, and the solid substance of the coagulum at last assumes the character of adipoceros fat. Sometimes two parts of water and one part of blood having been coagulated by fire, the liquor separated from the coagulum, evaporated slowly, yields a bilious extract : it was in this manner that I demonstrated the presence of bile in the blood in 1790.

10. The acids when mixed with fluid blood coagulate and decompose it, rendering its colour darker, and more or less brown when they are concentrated. The concentrated sulphuric acid renders it very brown and reduces it to coal. The nitric acid, whilst it coagulates it, disen-  
gates

gases from it much azotic gas, and converts its substance into carbonic acid, oxalic acid, and fat matter; the muriatic coagulates it without sensibly altering its colour; the oxygenated muriatic acid turns it black like ink. The vegetable acids only thicken it; the acetic acid is the only one of them which effects its coagulation. The caustic alkalis, on the contrary, liquefy and dissolve the blood even when coagulated by the acids; if we mix them with blood recently drawn and which has not yet coagulated, they prevent its coagulation. It has already been seen how the alkalis, heated strongly with this liquid, become in part saturated with Prussic acid.

11. Many salts have been mixed with the blood, and their effect has in general been found to correspond by the antiseptic property and the softening or liquefaction which they effect, as well as by the obstacle which they oppose to its coagulation. At one time this effect of the salts and of the saline solutions upon the blood was considered as an indication of their medicinal virtue; but this notion was soon discovered to be a real error, dangerous to the art of healing. The earthy salts in general are decomposed by the blood by means of the soda which it contains.

The metallic oxides have no sensible action upon the blood, except those which by easily yielding their oxygen coagulate it. Almost all the metallic solutions precipitate and coagulate the blood;

blood ; they act especially upon its albuminous part ; it is almost superfluous here to add that these two classes of bodies, the alkaline and the metallic salts, preserve the blood and defend it against putrefaction.

12. Most of the immediate materials of vegetables, and even of the entire plants, produce this latter effect upon the blood and act upon it as antiputrescent ; it is especially in sugar, the volatile oils, camphor, the resins and the balsams, that we find this property. The solutions of gum and of starch coagulate it.

Tannin precipitates the blood abundantly ; gallin and the pure gallic acid blacken it and form in it an atramentous deposition, which without any other experiment is sufficient to indicate the presence of iron in it. We may obtain this precipitate by diluting the blood with much water. At the same time the astringent property of the gallic acid and of the extract which accompanies it in the gall-nut, thickens, condenses and even hardens the solid matter of the blood ; the same effect is observed in all the astringent vegetable substances, particularly in Peruvian bark, Simarouba, the peel of the pomegranate, fumac, the outer shell of the wall-nut, tea, &c.

Alcohol, poured upon the blood, also effects its coagulation, but it precipitates it only in small flakes, which water separates and dilutes so as almost to dissolve them.

13. The

13. The blood, like all the other particular animal matters, has its mode and peculiar phenomena of putrefaction. Its colour grows darker and brown, it loses its consistence, its odour becomes insufferably fetid; there are separated from it a great number of membranous flakes, brown pellicles which gradually grow blacker; a considerable quantity of ammonia and carbonic acid gas is disengaged from it. It requires a very long time before it entirely loses its form, and characters of blood, before it becomes a solid, thick extractiform matter, and especially before it is reduced to a species of mould. There are then found in it nearly the same materials as in the coal which remains after its distillation or combustion, except that this residuum retains a greasy or unctuous feel, which announces in its alteration a well-marked production of fat matter.

### SECTION III.

#### *Of the Separation and Classification of the immediate Materials of the Blood.*

14. THOUGH all the chemical characters of the entire blood are not without interest, they are however not so well marked or so important as those which belong to its immediate elements, to the different materials which separate spontaneously

## BLOOD.

usually from it. It is known that this liquid, when left to itself as it issues out of the veins or the arteries of the living animal, presents, whilst it is hot and fluid, an odorous exhalation which has been considered as one of its principles; that it soon coagulates or concretes into a tremulous gelatiniform mass, which condenses, shrinks, gradually approaches in its parts, and expresses from itself a liquid of a yellowish white colour and transparent; that it then resembles a kind of curd, a floating red cake, which has been called *cruor*, *clot*, or *insula rubra*, that this formation does not take place in the same manner when the blood has been violently agitated; that by this agitation, which is frequently practised in the shambles, there is separated from the blood a remarkable quantity of fibrous matter, solid, whitish, and ropy, as it were, which attaches itself to the stick which is employed to stir it; that when the serum or the white part has been separated from the coagulum, this, washed with water thrown in a stream upon its surface, is separated into two matters, the one of a red-colour, dissolved in the water with which it has been washed; this is the colouring matter of the blood; the other, solid, white, filamentous, which is called fibre, or fibrine. Thus there are five matters to be examined in particular; namely, the odorous exhalation, the serum, the coagulum, the colouring matter and the fibrous substance. I shall first remark that  
immediate materials of the blood, when  
once

once separated from each other, or even two of them, the coagulum and the serum, insulated spontaneously, cannot again be united, or combined so as again to form blood, and that when once the connection is broken between them by their separation from the living body and the cessation of the vital motion, their primitive composition can no more be made to re-appear.

#### SECTION IV.

##### *Of the Odorous Exhalation of the Blood.*

15. I DISTINGUISH amongst the principles belonging to the blood the odorous exhalation ; in order to conform to the opinion of the most celebrated physiologists who have considered it as one of the most important elements of this liquid, and who have attributed to it very powerful effects in the animal economy. Some modern philosophers have thought that this principle was a particular gas, and it is according to this idea that Citizens Deyeux and Parmentier have made experiments upon this exhalation in their new analysis of the blood. It results from their experiments that this principle cannot be obtained insulated in the form of gas, that when it was condensed in a bottle of which the blood, which had been put in quite hot, filled one part, and of which the portion  
full



full of air received this odorous body : this air did not extinguish the tapers that were immersed in it ; that it did not precipitate lime water ; that it was however sufficiently strongly impregnated with the smell of blood to communicate it to water by agitation, to diffuse after some time a fetid smell, to extinguish these lighted tapers, without however containing ammonia ; that it was then a little less pure by the test of the eudiometer ; that the odorous water extracted from the blood by distillation on the water bath, and which yielded nothing to the re-agents, putrefied, deposited flakes, and turned the syrup of violets green ; that when it was heated in this state it afforded a sediment that burned upon the coals, with the smell of the retort. Blood, distilled with alcohol presented to them, in its volatile product, the very distinguishable odour which it emits when it has been poured into water ; yet this odorous alcohol showed no effect upon the re-agents. The chemists whom I have quoted thought themselves authorized to conclude from these experiments, that the aroma of the blood is the most alterable principle, and that which first changes the state of this liquid by escaping in the volatile form. In the phenomena that have been indicated I can see only a small portion of the entire matter of the blood raised in vapour with the water, and I find no relation between the experiments relative to this vapour and the uses that have been attributed to it. It has been

been erroneously believed that the froth formed by the blood, spouting out and falling from an eminence, was a proof of this gas: it is only air confined by the viscosity of this liquid.

16. Though I do not admit a particular principle of the odour of the blood; it is nevertheless of importance to know that this odour is one of the most marked characters, one of the most striking differences which are found in this liquid, considered under different circumstances. The odour of the blood is very feeble in infants and in females; it becomes very strong at the age of puberty, as soon as the feminal fluid is formed in abundance and collected in its reservoirs; it has then something strong, acrid and even fetid. The blood of eunuchs is deprived of it, as well as that of old men; accordingly some physiologists have believed that the smell of the blood and of the flesh, to which it communicates itself, is owing to the spermatic fluid volatilized, diffused in the cellular texture of the body, and penetrating into all its regions. Bordeu has ingeniously treated this remarkable subject as one of the symptoms of the spermatic cachexy, in his medicinal analysis of the blood.

## SECTION V.

*Of the Serum of the Blood.*

17. THE name of serum, water of the blood, and the improper one of lymph, are given to the liquid which separates from the coagulated blood when it has not been agitated; it is the thinnest and the lightest liquid contained between the interstices of the coagulum, and expressed out of its cavities by the approximation and attraction of the molecules of the cruor. The serum is of a greenish yellow colour, of a saline and insipid taste, of a consistence sufficiently viscid to glue the skin slightly, when rubbed between the fingers. Its proportion is very variable and cannot be fixed; however, several physiologists have attempted to determine its quantity. Hamberger supposed it to constitute a third of the weight of the blood; Schwenke believed it to constitute two thirds; Drelincourt and Boyle admitted it to be one half; Quesnay three quarters; Vieussens gave for the red part 0,62, and for the serum 0,38; Homberg indicated five parts for the serum, and three for the red matter. According to Robinson, it is much more abundant in young animals; the cruor or the red part augments with age, and a period arrives in which the

2

proportion

proportion of the serum descends to one third of the red substance. It is also said that the blood contains more serum after meals, and that when the individual is fasting it has much more solid matter. Lower and Haller attributed this effect to the chyle poured in by digestion. Muschenbroeck, Martyne, Schwenke, Jurin, indicate the specific weight of the serum compared with that of water as 1027 to 1000.

18. The serum exposed to the fire coagulates or hardens, and becomes opaque like white of egg. This property is one of the characters by which it is eminently distinguished; it is attributed to a particular matter easily recognizable by that circumstance, and which is called *albumen*, because it is the same which exists in the white egg called *albumen*. When it is gently heated in this state of coction or coagulation, the coagulated and solid substance becomes hard, brittle, and semi-transparent like horn. Heated by fire in the retort, it affords ammonia, carbonate of ammonia, fetid oil, sulphurated hydrogen gas, and a coal in which are found muriate, phosphate, and carbonate of soda. The serous liquor of the blood is also capable of turning the colour of violets green, which is likewise a property which it has in common with the freshest white of egg. According to these experiments, however simple they may be, the serum of the blood is considered as a combination of an albuminous matter with soda; a combination in which the  
alkali

alkali united with the albumen, preserves its properties as it does in soap.

19. The serum turns the syrup of violets green, and the tincture of curcuma brown; it constantly exhibits the alkaline properties; exposed to the fire, it becomes concrete at the temperature of seventy-five degrees of the centigrade thermometer. This phenomenon, which was first observed by Harvey, the immortal author of the discovery of the circulation of the blood, is one of the most important which this animal substance presents: every one knows it in the white of egg; but it differs sensibly in the serum, as this liquid, being not so thick as white of egg, neither acquires the same solidity, nor the same opaque whiteness in its concretion. Though it forms a mass, it is always tremulous; it is found filled with bubbles, and manifestly formed of two different substances when it has cooled after its coagulation; its colour is a pearl-grey, it retains a semi-transparency; there is observed in it a softer portion, less opaque, frequently interposed between the particles and in the middle of the most opaque grey mass, sometimes collected at its surface, especially when it has been coagulated slowly and by a well-managed fire. When this portion does not show itself in this manner, which is the case when the serum is too liquid and too aqueous, the part which does not become fixed, when evaporated and left to cool, concretes into a  
real

real jelly. The portion which, by the action of the fire, is congealed, and becomes opaque and insoluble, is called albumen, from its analogy with the white of egg; the more transparent matter which becomes fixed especially by cooling, and which is soluble in water, is termed gelatin. Chemists were unacquainted with its existence in the serum of the blood, till I discovered it to be present in it, in 1790. We shall soon see from whence the coagulation of the serous albumen proceeds: it is necessary here to observe, that its concretion by heat always leaves it viscid, gluey, tenacious, and not brittle, smooth and dry in its fracture, as we see in the white of egg hardened by the action of fire.

20. If we treat the serum of the blood by distillation on the water bath, it affords a very large quantity of water slightly odorous, in every respect similar to that which is obtained from the blood, and like it putrescible. The serum coagulated and dried in this operation is brittle, hard, almost transparent, and of a yellow, orange, or brown colour: when strongly heated and distilled in a retort, it affords water and fetid oil, carbonate of ammonia, partly concrete, and partly dissolved in water, a little Prussiate and zoonate of ammonia, carbonated and sulphurated hydrogen gas, and carbonic acid gas. There remains a very voluminous light coal, difficult to be incinerated, which contains, with the carbon, muriates of soda and of potash,

ash, phosphate of lime, and carbonate of soda. No metallic oxides are found in it. When the coagulated serum is slowly heated, in a retort, sulphur is sometimes separated from it, which Citizen Deyeux has also obtained from white of egg. A plate of silver immersed in it becomes black, whilst it is made to coagulate by the action of fire.

21. When exposed to the air, the serum of the blood absorbs oxygen from it, and exhales carbon into it, whereby a part of the atmospheric oxygen gas is converted into carbonic acid gas; in proportion as this liquid absorbs the atmospheric oxygen, it becomes more concrescible, more capable of being rendered solid by the action of the fire; it frequently becomes turbid, and deposits flakes already spontaneously concremented. It is for the same reason that white of egg which has been kept exposed to the air boils quicker than that which is fresh, that the serum of the blood of animals which respire is more concrescible than that of animals which respire little: I have thence concluded that the concrescibility, the plastic nature of this humor, proceed from the fixation or the intimate combination of oxygen. Of this we shall soon see other proofs. To this property of absorbing air, the serum owes that of frothing by agitation which it possesses. Long exposure to the air favours the spontaneous decomposition of this humor, and accelerates its putrefaction; it then exhales a very fetid smell, acquires  
a brown

a brown colour, becomes ammoniacal, and at last leaves a kind of dark-coloured residue, which remains for a long time fetid, preceded by a soft or entirely melted putrilage, which exhales a great stench. The septicity of this liquor proceeds so rapidly, that Bucquet could not determine whether it passed into the acid state before it acquired the ammoniacal character. It is preserved from putrefaction by all the means indicated in one of the preceding articles.

22. The serum of the blood unites with water easily, and in all proportions. The aërated water renders it slightly turbid, and a small portion of it concrete. Boiled water does not produce the same effect, but remains transparent. When we dissolve serum in ten or twelve parts of water, the liquor which results from it resembles milk, according to the observation of Bucquet : it is white and opaque ; it becomes rarefied, and rises over the fire like that liquid ; it yields by evaporation membraniform pellicles ; it is coagulable by the acids, &c. &c. The consistent and viscous serum has the property of rendering two or three parts of water solid ; for notwithstanding this addition, it is rendered concrete by heat, and the water does not separate from it, on account of the adhesion which it contracts with it. When this humour is diluted with five or six parts of water, and heated to ebullition so as to render the whole of the albuminous part concrete, the liquid that



is separated from it, when properly evaporated, affords afterwards by cooling, a jelly which becomes fixed. It was in this manner that I discovered the gelatin in the serum of the blood.

23. The metallic oxides do not unite with the serum in general; but those which suffer their oxygen to be easily disengaged from them, and which adhere but feebly with it, such particularly as the red oxide of mercury triturated for some time with the serum, pass again into the metallic state, or approach to it more or less; at the same time the ferrous albumen becomes thick, opaque, and more or less coagulated. This experiment, which I described in 1790, proves that oxygen favours the concretion of the albumen, and that, as I have already announced, No. 18, the plastic property proceeds from the fixation of this principle; so that the concreted albumen is a real oxide. When the metallic oxides are highly oxygenated, and adhere very little with the oxygen, their action goes so far as to burn and reduce the serum to coal. By this circumstance is explained the cathartic or even caustic effect of the metallic poisons. It is however to be remarked, that this effect of the oxides of mercury, of their disoxidation by the ferrous albumen, has a boundary, that it extends only so far as to cause them to pass into the state of black oxide, and that in this manner we may conceive why running mercury triturated with serum is extinguished or reduced to the state of

black oxide. In these two experiments compared with each other, we see a new proof of the different attraction of different portions of oxygen for the same metal. The first portion is taken by the mercury from the albumen, and the second by the albumen from the oxide of mercury.

24. All the acids coagulate the serum, separate from it the albumen in flakes more or less dense, and of a greyish-white colour, the more solid in proportion as the acids are more concentrated. All of them, after having produced this coagulation, remain in the supernatant liquor, in part saturated with soda, which they have taken from the serum: some chemists have believed, on account of this effect, that the soda was combined with the albumen as it were in a kind of soap, and that it was this that rendered it soluble in water. Rouelle the younger considered it, however, as being almost entirely insulated. Bucquet, on the contrary, maintained that it was intimately combined with it, and that even the acids took away only a part of the soda of the serum; in proof of which he adduced that the coagulum formed in this liquor by acid in great excess, contained still carbonate of soda after its combustion and incineration: this fact however requires to be confirmed. The coagulation of the serum by the acids is prevented by mixing with it, before it is added to the latter, a certain quantity of the solution of an alkaline carbonate; the

effervescence which the acid that has been added produces carrying off the caloric in order to reduce the carbonic acid to the state of gas, no longer permits the mixture to become heated, and consequently guards the albumen against the coagulation which it experiences without this addition.

25. Besides this general effect of the acids upon the serum, each of them has some peculiar to itself. The concentrated sulphuric acid turns it brown, and reduces it to coal; that which is diluted with water only coagulates and preserves it. The nitric disengages from this humour coagulated by fire, azotic gas, carbonic acid gas, Prussic acid gas, and converts the rest into oxalic acid and fat. The fuming muriatic acid communicates a violet colour to the serum, or coagulates it; by a long contact it becomes saturated with ammonia by decomposing this substance. All the other acids precipitate, coagulate, and preserve the serum; ammonia easily dissolves the albuminous coagulum formed in the serum by their action.

26. All the earthy and alkaline bases have actions more or less marked upon the serum of the blood. The solutions of barites, of strontian, and of lime, precipitate this liquor; the precipitate is a real insoluble phosphate. The leys of fixed alkalis render the serum more liquid; with the aid of heat they dissolve its coagulated albumen. The caustic and dry pot-ash or soda, triturated with this liquor when  
thick

thick or boiled, suddenly disengage ammonia from it, and dissolve a part of the remainder. When these alkalis are heated and calcined with coagulated serum, the ley which is made of the residue of this coagulation, is found to contain Prussic acid, and precipitates iron in the blue state. When the serum is boiled with an alkaline ley much diluted, and when this liquor is filtrated, the weak acids poured into it disengage from it a very perceptible smell of sulphurated hydrogen gas: this is one of the proofs which Citizen Deyeux has adduced to prove the presence of sulphur in the serum of blood, which is besides manifested by other experiments that have already been indicated.

27. Serum combines with most of the saline solutions, without experiencing any alteration from them, except being preserved and defended against putrefaction. It however decomposes the calcareous salts by virtue of the soda and phosphate of soda which it contains; the precipitate which it forms in it is a compound of lime and phosphate of lime. The soluble baritic salts produce no effect upon it. Those of strontian are decomposed, and their base is precipitated by soda. The same is the case with the salts of alumine, of zircon, and of glucine. The soda of this liquor separates also the ammonia from the ammoniacal salts, and this volatile alkali seizes the albumen of the serum, which it dissolves, or at least renders more fluid.

28. I have

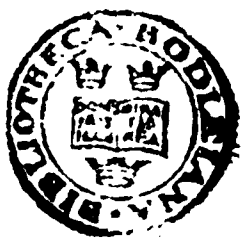
28. I have already said, that the metallic oxides thicken and coagulate the albumen; and it is evident that, combined with the acids, they must produce this effect in a still more powerful manner, as they are aided by the latter, which themselves also produce it in a very marked manner. When we pour a metallic solution into the serum of the blood, there is suddenly produced in it a thick and coagulated precipitate, formed by the metallic oxide and albumen. But besides this, the muriates, the phosphates, and the soda which it contains, occasion another kind of decomposition in the metallic salts: so that the precipitate which they form in them is generally composed of four substances, the oxide separated by the soda, the oxide united with the albumen, a muriate and a phosphate of the same oxide. Such especially is the effect of the nitric solutions of the white metals, of mercury, of lead, and of silver; the latter also shows the sulphur in it by the black streaks which it forms in it. These precipitates, especially that of mercury assume a rose or flesh-coloured tinge. The serum treated in this manner has become unalterable and imputrescible. There are some metallic salts which are capable of uniting with the serum without decomposition: such especially is the phosphate of iron with excess of oxide, which colours it red.

29. Some vegetable matters act in a particular manner upon the serum. Alcohol coagulates it

it and precipitates it in small whitish flakes, which easily divide in water and remain so well suspended in it that we might consider it as dissolved. Bucquet had even announced that the coagulum formed by alcohol was entirely soluble in water, and disappeared when a sufficient quantity of this liquid was added. The fixed oils are rendered miscible with water by the serum of blood. The volatile oils, camphor, the resins, the balsams, and the gum-resins, preserve this liquid, and prevent its putrid decomposition. Tannin is of all the immediate materials of vegetables that which has the most remarkable action upon the serum of the blood: it precipitates itself abundantly into a yellow, gold-coloured, ropy, and pitchy substance, insoluble in water, which dries and becomes brittle in the air; which has no longer any kind of alterability; and which resembles leather too much tanned and become dry, hard and brittle, by excessive tanning. The gelatin and the albumen are equally precipitable by tannin, but the first is more easily dried than the second; and though the distinctive characters of these two tanned substances have not yet been determined, it is no less certain that they present reciprocal differences which may hereafter serve to distinguish the one from the other, perhaps even to separate them, and estimate their proportion.

30. All the facts relative to the properties of the serum of the blood prove, that this liquid is  
a kind

a kind of animal mucilage, composed of albumen and gelatin in different proportions, dissolved in a variable quantity of water, constantly combined with pure soda, which is united with the albumen almost in a saponaceous combination: we also find in it muriate of soda, phosphate of soda, ammoniacal phosphate, and phosphate of lime. The latter appear to be not essential to its combination: not only their proportion varies; but they may exist or not exist, be in the number indicated, admit of the absence of some of them, or the simultaneous presence of a greater number. For example, we may find in it muriate of pot-ash, phosphate of magnesia, or ammoniaco-magnesian phosphate, &c. without the albuminous alkaline and gelatinous matter of the serum of the blood changing or presenting properties foreign to those which characterize it.



## SECTION V.

### *Of the Coagulum or Cruor.*

31. WHEN the blood, after several hours coagulation, has afforded all the serum that can run, and be expressed from it, the coagulated, half solid, and contracted substance which swims in the middle, is known by the name of

of *coagulatum, placenta, insula*. This mass has been called *cruor* before the means of separating it into the two different matters which constitute it, had been discovered.

It appears that the differences of proportion between the serum and the cruor, that have been admitted by the different authors, are owing to its variable quantity, Wieussens estimated it at 0,62, and gave only 0,38 to the serum; Homberg gave five parts to the latter and three to the cruor; Schwenk reckoned the serum at two-thirds, and the cruor at one-third; Quesnay the serum at three-fourths, and the cruor at one-fourth; Senac the serum at four-fifths, the cruor at one-fifth; Schwenk admitted it to be only one-eighth. Boerhaave adopted the latter proportion. In general physiologists, according to Haller, think that the cruor increases as the individual advances in years; that the serum predominates in young animals; that those which are vigorous afford more cruor, and that when they are debilitated or badly fed, this matter diminishes in them. Nevertheless it results from this comparison of opinions and facts, that the cruor or the substance of the coagulum is in general less abundant than that of the serum. It is also to be observed that the proportion of this solid or cruoric part of the blood diminishes more the longer we leave the serum to separate, and that it always tends, by shrinking



shrinking together, to press out a larger portion of the gelatino-albuminous liquid.

The blood coagulates, or assumes the concrete state in close vessels as well in open ones, in the heat as well as in the cold; it is therefore, neither the air nor refrigeration which coagulate the blood, but the privation of the vital motion.

This coagulum is formed sooner or later; its consistence varies from the tremulous softness of currant-jelly to the solidity of a kind of leather. In youth and in females it is softer; in old age its tenacity is very great. When the blood becomes covered with a buffy coat in some particular dispositions of the subject, or in inflammatory affections, it is observed that the coagulated and red part which it covers is less solid and less abundant; which proves that the substance of this coat, is formed at the expense of that which forms the solid part of the coagulum. Blood received, as it issues out of the vein, into a solution of salts, nitrate of pot-ash, or sulphate of soda, does not coagulate.

Its surface which is in contact with the air is of a brilliant purple-red, its interior is dark coloured and almost black; but this interior part, when exposed and opened in the air, assumes the clear and brilliant tinge of the surface. Inclosed in a vessel full of atmospheric air, the coagulum quickly alters it, whilst it becomes red, and converts the oxygen into carbonic

bonic acid. Hydrogen gas and carbonic acid gas give it a violet colour; the first of these gases becomes carbonated.

The coagulum corrupts rapidly and becomes insupportably fetid. In a hot place, as a stove or an oven, it dries without putrefying, and becomes converted into a kind of powder. Thrown into boiling water it acquires more consistence than it naturally has; its colour passes into an homogeneous brown; the water becomes turbid, and presents at its surface an abundant scum; the acids thicken and harden it, at the same time rendering it brown. Alcohol heated upon the coagulum assumes a lemon colour and condenses its texture. The alkalis on the contrary soften and dissolve it; they change its colour less than the acids.

32. The coagulum being tied in a bag of linen, and washed under a stream of water till this ceases to be coloured by it, when the linen is slightly compressed between the fingers, separates into two distinct substances, precisely in the same manner as we have seen the paste of the flour of wheat separated into two substances by the same operation. We may also effect this separation in the hand by using only a very small stream of water, or upon a very close hair sieve always with the same precaution of employing but very little water, and receiving it gently upon the surface of the coagulum. These two matters are, 1. the red colouring part which dissolves in the water and runs off

in the washing; 2. a white solid substance, filamentous and flaky, which remains in the bag, in the hand or upon the sieve, and which is much less voluminous, and at the same time much more dense than the coagulum. There is this very perceptible difference between the product of this operation and that of the washing of the paste of flour, that the wheat yields starch in powder; which renders the water turbid and milky; whereas the coagulum does not render water opaque nor leave any fecula precipitated, but permits the red colour to dissolve in the liquid, which passes off transparent. By pursuing this comparison, we see also that the white concrete substance obtained as residuum of this washing corresponds with the glutinous part of wheat, and that the coloured liquor of the cruor that has been washed represents at the same time the amilaceous fecula and the mucofo-saccharine matter of the flour.

## SECTION. VI.

### *Of the Colouring Part.*

33. THE water which is employed for washing the coagulum of the blood, takes from it the whole of its colour and acquires a more or less brilliant-purple tinge. This is what is termed the colouring part of the blood. It appears to be

be nothing more than a dilute solution of albumen and gelatin, with which a small quantity of iron, in the proportion of a few thousandths is mixed. It is thus that Bucquet has described it, comparing it with the serum, from which it appears to differ only by the metal thus indicated. This definition could not enable us to understand the adhesion of this ferrugineous serum with the coagulum, and the separation of the white serum which is effected, except as a simple expression of the thinnest and most fluid part of the liquid, and as the more intimate attraction of the portion condensed by the oxide of iron for the concrete and fibrous part of the coagulum. But such a general or superficial notion is not sufficient; we must study with greater attention the properties of the sanguine colouring liquor, and investigate those which particularly characterize it.

34. The aqueous ley of the coagulum, which is transparent at the moment when it has just been obtained, becomes turbid and deposits membranous flakes at the end of some time; it turns the syrup of violets green. Even when heated on the water-bath, it forms a brown coagulum, which swims in a turbid water. This coagulum separated from the liquid portion by filtration, pressed and dried, becomes brittle, pulverulent, insipid and inodorous. We see it in what is called the *scum of the pot*, when the entire flesh is boiled in water. Alcohol takes from

from it but very little, and assumes a red colour. The acids blacken and alter it, they also form it and separate it from the water by coagulating it. The pure alkalis dissolve it, and it is precipitated from them by the acids. The coloured coagulum affords in distillation the same product as that of the white serum, and it presents so many analogous properties that it is impossible not to confound it with the albumen of the former liquor. One difference however presents itself when we compare their coats, since that of the red serum contains iron, as shall be shown.

35. When we separate, by the action of fire, the ferrugineous albumen from the large quantity of water in which it is dissolved, whatever temperature may be employed, and whatever time we may bestow upon this separation, we can never obtain it entire; because the part which is coagulated fixes about a fifth of water in which it was dissolved; the supernatant liquor also retains a portion of albumen, and there is established an equilibrium of combination, a mutual partition between these two bodies. Also by evaporating the liquor that is not thickened, after having separated it by filtration from the solid and coagulated matter which it contained, it presents at its surface towards the end of the evaporation, a brown pellicle, which breaks and is precipitated into coloured flakes. When it is dense and clear, alcohol heated upon it dissolves a part of it, assuming a deep brown colour,

colour, and leaves by evaporation a residuum of animal matter, soluble in water, frothing by agitation, like a solution of soap, strongly turning the colour of violets green, and precipitated by the acids. These last properties indicate that the albumen combined with soda actually resembles a saponaceous combination.

36. When Menghini discovered the presence of iron in the blood; when Rouelle confirmed it by new experiments; neither of these chemists determined in what state this metal was contained in it. Citizens Deyeux and Parmentier believed it to be combined with soda, and in a state nearly resembling that of the ferruginous alkaline tincture. The following is the manner in which Citizen Vauquelin and myself found that the iron was united in it with phosphoric acid, as Citizen Sage had announced a long time before, but without proving it, and as Mr. Grew, Professor at Halle, had asserted more positively, though he did not indicate by what means we might be convinced of it. When the red part of the water in which the coagulated blood has been washed is burned in a crucible, we obtain a residuum of a dark red colour, forms 0,0045 of the blood that has been employed, but which, when dissolved in the muriatic acid, amounts only to between 0,0017 and 0,0006 when separated from what is foreign to it, or those saline matters which do not contain iron, by the following processes. It is digested in very weak nitric acid, which dissolves

dissolves a part of it, and leaves another more red than before. Ammonia poured into this solution affords a white precipitate, which when treated whilst still wet by caustic pot-ash, loses part of its weight, and assumes a very dark-red colour. Lime water, poured into this ley of pot-ash, forms a white precipitate of phosphate of lime. We may employ muriatic acid for dissolving the phosphate of lime, which remains after the combustion of the coagulated red serum.

37. In order that we may be the better able to conceive the nature and the state of this phosphate of iron, and understand how it can be dissolved in the blood along with soda, it must be observed, that there are two phosphates of this metal, the one white-grey, frequently of a pearly brilliancy, insoluble in water, soluble in the acids, and the other red, more or less brown, and less soluble in the acids; this is phosphate with excess of oxide of iron, and the other is saturated with its acid. The white phosphate of iron is decomposed only in a partial manner by the caustic alkalis, which take from it only a part of its acid, and leave the salt with an excess of this base. It is in this state of phosphate supersaturated with iron, a state maintained by the presence of the soda, that this metal is dissolved in the blood, and in particular in its serum. The blood of all animals, when it is red, is coloured by the phosphate of iron.

38. We

38. We have found in our experiments relative to the colouration of the blood, that the super-oxygenated phosphate of iron has an excess of its base, that this phosphate dissolves very well, and by the slightest agitation or trituration, in raw white of egg, and in the serum of the blood: it is not even necessary to employ the aid of heat in order to effect this solution, since it takes place in the cold by mere motion, presenting immediately a very strong red colour, which resembles that of the blood. A little pure fixed alkali accelerates this solution, and renders its colour more perfect and lively. Thus the phosphate of iron, the quantity of which, though very small, is sufficient to colour the blood, exists in it in the state of super-oxidation, and of excess of metal; it is dissolved in its albumen, and brightened by the soda contained in it. Perhaps the phosphate of soda existing in the serum has no other origin than the partial decomposition of the phosphate of iron by the soda.

39. Amongst the properties which distinguish the red serum, or the colouring part of the blood, we must particularly mention its change of colour by the contact of the air; the lustre imparted to it by the oxygen gas, or the aerated water employed for washing the coagulum; the violet brown, which it contracts from carbonic acid gas, and especially from carbonated hydrogen gas; the influence which it has upon the alteration of the air, the formation of carbonic acid which it excites, and the absorption of oxygen which it produces. If these phenomena



are more energetic and more prompt in the red serum than in the white, and if the difference which exists between these two species of serum entirely depends upon the presence of the super-oxygenated phosphate of iron which the first contains, it is evident that this metallic salt is the cause of the colouration of the blood, and of the lustre which this colour acquires by the contact of the atmosphere, as also of the changes which this red serum, at the same time, occasions in the air in which it is immersed.

40. Citizen Deyeux believes, that the colouring matter of the blood, besides albumen, gelatin, the phosphate of iron, and the salts, which analysis has discovered in it, contains a particular substance, to which he attributes several of its characters, and especially the homogeneous concretion of the entire blood in the preparation of puddings; on which account he calls this substance *matière tomelleuse*. It is since his investigations concerning the blood that he appears to have directed his attention to this matter, as he had said nothing at all of it in the *Journal de Physique*, in which his first analysis is inserted. He has distinguished the tomelline; for it is useful to give to his name a termination similar to that of several other animal substances, with which it appears to have much analogy in its form, its consistence, as well as in several properties which have appeared to him to be different from those which are known in the albumen, the gelatin, and the fibrine.

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But he has himself given the first notions relative to this particular matter, only as mere ideas, which deserve to be verified and pursued, in order to receive from experience, that confirmation which alone can prove the existence of this new body.

41. I must not omit, amongst the properties of the colouring matter, or of the red serum of the blood, that of dissolving copper, which presented itself to Citizen Vanquelin with so remarkable an energy as to induce him at first to believe that the blood contained this poisonous metal amongst its principles. The following is the manner in which this discovery presented itself to him. Having boiled the water in which the blood had been washed in a very clean copper kettle, in order to coagulate the albumen, and having filtrated the liquor, in order to collect separately the coagulated matter, with the intention of carefully examining its colouring part, he burned this concrete substance in an earthen crucible, and dissolved its ferrugineous residuum in the muriatic acid. When he attempted to precipitate the solution by ammonia, he was much surprized to see the liquor, which contained an excess of this alkali, assume a beautiful blue colour. The liquor was saturated and discoloured by the muriatic acid, and a plate of iron that was immersed in it became covered with a brilliant stratum of copper, the quantity of which was sufficiently considerable after two days to be able to be separated and

detached from the iron. The water from which the coloured albumen had been separated by coagulation, contained no copper; whence Citizen Vauquelin concluded that the solution of the copper was owing to the albumen; that it was effected at the moment of the separation of the albumen by the heat; that the copper combined and precipitated itself with the concrete albuminous matter. In fact, this more oxygenated part of the blood exerts a very marked attraction upon the metallic oxides, combines with them with considerable force, and separates them, as we have seen, from the acids. According to this fact, it is an important caution, that blood prepared for food should not be boiled in copper vessels. It is also to be observed, that in precipitating an alkaline ley of blood by the acids, we obtain more Prussiate of copper than even Prussiate of iron. The first is recognized by its purple-red colour when it is moist, and its dark-red colour when dry.

42. The red serum of the blood, or the colouring part of this liquid, obtained by washing the coagulum, after the separation of the serum, or of the white ferous part, is therefore composed of a large quantity of water, of albuminous and gelatinous matter, of super-oxidized phosphate of iron, of soda, and of some saline substances. The latter, and particularly the phosphates and muriates, are much less abundant in it in their proportion with the albumen than in

in the serum properly so called, since this, which has flowed spontaneously out of the coagulum, and which was its most fluid part, must have carried off with it all the more soluble parts that were contained in it, and the salts hold the first rank in this order. It is very evident that we do not speak here of the proportion of the materials of the red serum to the water which dissolves them, as we may consider it in the white serum, because the quantity of the water added, depends entirely upon the will of the person who operates, and the process which he employs. The super-oxygenated phosphate of iron, or the red phosphate of iron, which colours this serum, separated from the coagulum, is dissolved in it by the albumen, and is precipitated with it when the fire coagulates and separates it from the water; this albumen retains even a part of its dissolvent activity, since besides the ferruginous salt which it naturally contains, it re-acts so quickly and so powerfully upon the copper, and undoubtedly upon other metals. We may understand the simultaneous presence of phosphate of iron, and of soda in the blood, when we know the fixed alkali decomposes this metallic salt only in part, and reduces it, like the Prussiate of iron, only to the state of phosphate with excess of iron, or red phosphate, and that it is in this state in the blood; we comprehend it still better when we recollect that iron, which is oxidized in a solution of phosphate of soda, decomposes a part of this salt, and passes  
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into the state of super-oxygenated phosphate of iron. Perhaps, it is also in this manner, that this ferrugineous salt is formed in the blood, and that the separation of the soda is effected.

## SECTION VII.

### *Of the fibrous Part of the Blood, or of the Fibrine.*

43. WHEN the coagulum, tied in the linen bag, has been well washed, there remains a white matter in hard filaments, interlaced with one another in a texture resembling felt, which has been called *fibrous matter*, and which is denominated *fibrine* in the methodical nomenclature. This substance separates itself from the blood when it is agitated in the shambles, and attaches itself to the sticks with which it is stirred, in the form of small solid fasciæ, twisted together like intermingled threads, of a rose-colour, which become white by washing. We constantly find it still floating in small flakes, or in whiteish fibres, in the water into which the blood is received in blood-letting at the foot; sometimes similar filaments come away with the blood in venesection at the arm, and it cannot be doubted, that to these filaments are to be attributed the pretended worms which have  
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been said to have seen issuing out of opened veins.

44. The fibrine when well prepared, drained upon paper without size, and dried in a stove, thereby loses two-fifths, or between 0,39 and 0,40 of its weight. The medium quantity of this matter, taken from the blood of six different persons, amounted in our experiments to 0,0028; in the blood of a greater number of persons compared, the *minimum* of its proportion was 0,0015, and the *maximum* 0,0043. The fibrine is void of taste, and of such consistence and tenacity in its texture, that animals cannot masticate it without much difficulty. When it is exposed suddenly to a violent fire, it shrinks and moves like parchment. When distilled by naked fire, and in a retort, it affords water charged with carbonate of ammonia, a thick, heavy, and very fetid oil, and much concrete ammoniacal carbonate. There is also disengaged from it carbonated hydrogen gas, and carbonic acid gas: it is one of the animal substances which furnish the most oil and ammonia; accordingly, I have indicated it as a substance particularly azoted. The coal which it leaves after its distillation is compact, heavy, and rather difficult to be incinerated. We find only phosphate of lime in its ashes; we extract it and ascertain it by dissolving it in the nitric acid, and precipitating it by ammonia. It contains neither soluble phosphate nor iron.

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45. The fibrine putrifies quickly and violently in water; it exhales a fetid smell, and is converted into an adipocirous fat substance; there is also disengaged from it much carbonate of ammonia during its putrescence. It is not soluble in water, and when left for a long time in this liquid in the boiling state, it becomes hard like horn, assuming a grey colour. The alkalis, diluted with water, have very little action upon it; it is equally insoluble in ammonia. The leys of caustic fixed alkalis, barites, potash, soda, and strontian, highly concentrated, attack it, however, with the aid of heat; they give it a brown-red colour, disengage ammonia from it, soften it, and at last entirely melt it. The result is a kind of bitter fluid and viscous soap, which the acids and the metallic salts decompose.

46. The acids have a much more sensible action upon the fibrine. Even the weakest dissolve it. Weak nitric acid disengages from it in the cold much azotic gas, afterwards with the aid of heat Prussic acid gas, and carbonic acid gas, mixed with nitrous gas; there are then formed yellowish fatty flakes, and the liquor holds oxalic acid in solution. The concentrated sulphuric acid reduces it to coal, converting it in part into water and acid. The muriatic dissolves it, and gives it the form of a green jelly. The acetous acid also dissolves it, like the citric, tartarous, and oxalic acids, with the

the aid of a gentle heat. All these acid solutions assume, when they are concentrated by evaporation, or otherwise well saturated, and by cooling, the gelatinous form: they then resemble a real jelly. The alkalis precipitate the fibrine from these acid solutions in flakes, altered indeed, and which have become soluble in hot water; it would then seem that it has assumed the character of gelatinous texture, and that it has experienced a kind of retrogradation in its composition.

47. We must add to these properties, which are already very capable of characterizing the fibrine, and distinguishing it from the other animal substances, that it affords, amongst the products of its distillation, a remarkable quantity of the zoonic acid, discovered by Citizen Berthollet, and that it thus exhibits, in the experiments to which it is subjected, a very animalized matter, very much azoted, especially which represents almost the last term of animalization, or of the animal composition. It is, perhaps, to an alteration of this substance, analogous to what takes place with it in its conversion into zoonic acid, that we have to attribute the acidification observed by Citizen Chauffier, who asserts, that he has extracted a particular acid from the coagulum treated by alcohol.

48. Notwithstanding the small quantity of fibrine contained in the blood, we shall see hereafter, that it acts a very important part in the animal organization, and in the life of animals,  
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since it deposits itself in their muscles, the particular texture of which it constitutes, and since it becomes the seat of one of the most important and most incomprehensible vital functions, that of irritability, and consequently the principle of the motion which presides over all the other functions, from that of the heart, in which the support of life resides, to that of the smallest muscular fibre.

### SECTION VIII.

#### *Of the principal Differences of the Blood.*

49. It is not sufficient to have examined the entire blood, and its different elements, or immediate materials in the most general circumstances, or to have determined its properties, that are in some sort mediate or common. Chemistry can proceed still much farther; it ought to embrace a still much greater whole, and apply itself to much more extensive details. It is its business to appreciate the differences which this vital liquid presents, according to the places which it occupies in the body, according to the ages and the sex which modify it, according to the different orders of animals to which it belongs. Though the analytical labours which these data require, in order to be obtained, are yet but small advances,

advances, chemical knowledge has, nevertheless, already thrown some light upon these considerations; and it is important to collect those lights, as it were, into a focus, in order at least to illuminate the entrance of an immense course, which medicine expects in this respect from Natural Philosophy, which must precede her in this route hitherto so little frequented.

50. The ancients had some notions concerning the difference of the blood contained in the two orders of arterial and venous vessels: by admitting in the first, a spirit, or an elastic air, they seemed to have considered the blood which circulates through them, as rarefied, aerated, and frothy. It is no longer doubted, since Harvey, that the blood of the arteries is more red, more hot, more rare, and more irritating than that of the veins, and pneumatic chemistry has shown, that in fact the arterial liquid owes these properties to the oxygen gas which it absorbs in the lungs, and to the loss which it has there suffered of a portion of its hydrogen, and of its carbon. In proportion as it circulates, it loses both its heat, and its oxygen, and its proportions; so that having become of a brown-red colour, less hot, less concrescible, more hydrogenated, and more carbonated in the veins, it is disposed to become oxygenated, heated, dis-hydrogenated, and decarbonated in the pulmonary vesicles; and we shall see that respiration has these simultaneous effects, as its object and its function.

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51. To this difference of the blood in the system of the arteries, and in that of the veins, we must add that which it acquires in the different regions through which it circulates. It has been believed to be more light, more aërial, more spirituous in the vessels of the head, and disposed thereby to form the nervous fluid or the vital spirit, which as yet is indeed only an hypothesis. It is known, that it is fat and oily, or at least very much disposed to become so in the abdomen, and especially in the system of the vena porta; that it also undergoes a change that has not yet been appreciated in the spleen; that it is very much attenuated, and replete with life and activity in the spermatic system. There is also no doubt, that it has a very particular character in the vicinity of the kidneys, and especially where it issues out of this urinary organ, and in the emulgent veins, though it is not known in what this character consists. It is no less evident, that near to the heart, and before it enters it in order to be sent into the aëriferous apparatus of the lungs, the chyle which it receives, modifies and renovates it by furnishing to it a pure source of continual reparation. We cannot mistake the particular disposition which it has to become solid and converted into fibrous texture, which it affects by being retarded in those arteries, almost always retrograde, which carry it into the muscular flesh.

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52. Mere inspection is sufficient to show, that the blood varies according to the age and sex of the individuals. That of the foetus differs essentially from that of the infant after respiration has commenced, because the air has not yet touched or impregnated it. Already the first experiments which I have been able to make upon this subject, have shown me that the blood of the human foetus which has not yet respired, contains instead of the fibrous matter, only a softish texture, without consistence, and as it were gelatinous; that it is not susceptible of being reddened by the contact of the air, like that of the adult, and that it presents no phosphoric salts.

Sometime after birth the blood assumes a bright colour, a more considerable concrescibility, and it becomes enriched with phosphates, especially with that of lime, which being furnished in considerable abundance by the milk of the mother, quickly carries the solid matter to its bones.

At the age of puberty the blood is more hot, more highly coloured, more irritating, more odorous, and vivified by the spermatic emanation which prevails; moved with force in its strainers, it tends to escape from them: and this is the epocha of turgescence and of hæmorrhages.

The blood of the subject that has become adult, and in the permanent vigour which succeeds youth, has more consistence and more fibrous matter.

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In old age, it loses part of its energy, its heat, and its plastic property, but it becomes more disposed to be detained, and to form concretions of several kinds.

The blood of the female preserves for a long time the character of the blood of youth; it has been supposed, that the uterine and the menstrual blood have some particular qualities, a distinct smell and vapour which act at a distance upon flowers and fruits, upon liquors in the state of fermentation, the colouring matters, &c. When we separate from this opinion what is erroneous and exaggerated in it, it presents to the impartial observer something true, which ought to be ascertained by exact experiments, instead of denying what has not yet been comprehended.

53. The different orders of animals have certainly differences in their blood, proceeding from those of their nourishment, of the digestive, respiratory, &c. organs. The chemical investigations by which these differences are to be ascertained, have hardly been commenced; we have yet only very few general observations upon some of the properties of the blood, compared in the different orders of animals.

A. That of the mammalia approaches very near in its nature to that of the human species; like the latter, it contains a white serum, serum coloured by super-oxidated phosphate of iron, fibrine, muriates of soda and potash, phosphates of soda, and of lime and soda, the proportions

portions of which vary in each particular animal, as Rouelle the younger has shewn, by giving a table of the quantities of salts which he had extracted from the blood of the horse, the bullock, the ass, the calf, the sheep, the goat, and the hog. This chemist was much astonished, that the animals which eat vegetable food, and consequently pot-ash, constantly presented free soda in their blood; however, it is easy to conceive, that the pot-ash ought to decompose the muriate of soda. He found no phosphates in it; for the knowledge of these we are indebted to my analyses made since 1780.

*B.* The blood of birds is in general more red and more hot than that of the mammalia, and very quickly becomes fixed or coagulated; its coagulum is gelatinous; it does not separate from the serum except with difficulty. Its colour is never so brown or so dark as that of the blood of men, and of the mammalia. No comparative analysis has yet been made of it; we know neither the proportions of its parts, nor the salts that are contained in it.

*C.* The blood of the amphibia, and of the fishes, is as little known as that of the birds; no chemist has yet examined it; we only know, that it is colder, very little superior to the temperature of the air or the water in which these animals live, that it is little concrescible, and that it appears extremely disposed to become oily.

*D.* As

*D.* As to the mollusca, the insects, and the worms, it has been believed, that they have a white or little coloured blood, but no experiments have been made in order to ascertain the characteristic properties of this liquid. However, there exists in several of these animals a red blood, analogous in its appearance to that of the preceding. It is needless to observe, that an exact analysis and comparison with that of the kinds of blood already, will throw much light upon the functions of these beings.

## SECTION IX.

### *Of the Alterations of which the Blood is susceptible.*

54. ONE of the most important results which medical philosophy expects from the researches of chemistry respecting the blood, consists in appreciating the changes and alterations in the different morbid affections; but these researches have scarcely been as yet commenced. Citizen Deyeux and Parmentier have just begun to examine the blood in some diseases. They have found in general that the albumen is the element the most altered in this liquid; they have made some experiments

ments upon the blood of subjects attacked with inflammatory diseases, with scurvy, and with putrid fever.

55. The blood, which is called *inflammatory*, taken from pleuritic patients, presented to them a buffy coat which covered its surface, a soft coagulum, a coagulation as it were partial, filamentous and interrupted in the heated albumen, the impossibility of causing it to coagulate in boiling water, and the property of giving it a milky colour. The buffy coat appeared to them to be formed of the fibrin altered, softened, melted into a kind of gelatin, soluble in the acids; accordingly the blood upon which it is formed presents a very soft coagulum, which scarcely affords any fibrin when it is washed, or which dissolves almost entirely in water. We see that the inflammatory character of the blood consists in melting, or liquefaction of the fibrous part and of the albuminous matter, instead of the thickness and coagulation which had been supposed to exist in it, and that the substances which, in the healthy state, tend to concrescibility and separation have lost this property. I do not however consider it as demonstrated that the buffy coat proceeds from the fibrin; it appears to me more natural to consider it as super-oxygenated albumen, which carries with it a portion of fibrin on account of its concrescible power, whilst in the natural state it is the fibrin which retains a portion of the albumen.



56. The blood of three scorbutic patients, which had been drawn on account of the pain and the plethora which existed in these persons, from twenty-nine to forty-seven years of age, exhibited to Citizens Deyeux and Parmentier phenomena different from those which had been announced in this liquid. It had neither a greater fluidity than in the ordinary state, nor the absence of coagulation; it became concrete; its albumen was less concrescible by heat. The coagulum washed with water afforded fibrin in elastic filaments; upon one of them there was formed a buffy coat, only less thick than in the inflammatory blood, and which became friable by desiccation; the water in which the coagulum had been washed, or the colouring part, afforded membranes that floated in it. This blood had not its usual smell: the white serum was separated from it in the accustomed manner, and was not more abundant than in the ordinary circumstances. For the rest, the chemists of whom I speak believe that only erroneous inferences can be deduced from the quantity of serum separated from the coagulum of the blood. According to them, its spontaneous effusions in the hemorrhages so frequent in scorbutic patients do not proceed from its fusion and greater fluidity, but from the weakness and relaxation of the vessels which contain it. There is reason to believe, that a want of oxygenation is the principal character of the blood in scorbutic patients, and that it is on this

this account that this liquid forms the violet spots upon the skin, and that the sea scurvy begins with a considerable degree of corpulence.

57. The blood taken from the product of venesection at the arm, performed during the first days of the attack of putrid fevers, and in subjects with whom the symptoms manifestly indicated this disease, presented to them sometimes a buffy coat, and sometimes none; the serum generally appeared to them difficult to be separated, and adhering very strongly to the coagulum. They found it likewise either very marked analogies with that of inflammatory fevers, or nothing particular; they in vain sought to discover in it those signs of putridity with which so many authors have asserted that is tainted in this kind of affections, and to which they have attributed their cause. Distilled on the water-bath, this blood afforded them no ammonia, as might have been expected; exposed to a mild temperature, it did not putrefy more rapidly than the blood of a healthy person. According to them, therefore, there does not exist in it any particular principle of putridity, which has so often been said to characterize the diseases of this kind. It is only in the excrementitial liquors that this tendency to septicity, and even an incipient putrefaction, appear in putrid fevers: the blood does not partake of this property.

58. The chemists, of whose labours I have just given an account, have confined themselves merely to those researches, because the Society of Medicine, to whom they have addressed their Memoir, had spoken only of those affections in the programma of the prize which has been awarded to them. But how many other important questions still remain to be treated! how many useful problems to be resolved in this kind of experiments! The blood has a very remarkable character in those purulent diseases, in those great internal suppurations in which it appears to be converted so easily and so speedily into pus. Another presents itself, of equal importance to be determined, in chlorosis or the green sickness of young women, whose arteries and veins are filled with a liquid scarcely sanguine, of a light rose colour; and sometimes white. With dropical patients it has already been seen dry, gluey, viscous, and brown; it cannot be doubted that it has suffered a kind of decomposition which shows itself especially by the separation of the serum; for the water of hydropic cases has the greatest analogy with this humour. The affections in which the super-abundant bile accumulated in its canals, seems to diffuse itself into the sanguineous system, as physicians have long since observed, present to chemists an useful opportunity for ascertaining whether the means of their art will lead to the demonstration of the  
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presence of the bile in the blood. The same is to be said of the melaena or morbus niger, of the adipose and lacteal cachexies, and of a multitude of other affections in which the blood assumes a particular character, which is known by the practical observer, and which awaits from chemistry a more exact determination, a more positive definition, than mere inspection has hitherto been able to furnish.

### ARTICLE III.

#### *Of the Lymph.*

1. THE lymph is a white transparent liquid, contained and circulating in an order of vessels very well known at present, the extremities of which, opening into all the cavities, suck in or absorb the liquor effused by the extreme arterial ramifications, and the trunks of which unite with the reservoir of Pecquet and the thoracic duct; so that the lymph appears to be taken up at the extremities of the arteries, and carried into the veins. This humor is one of the most abundant in the body, as the canals which contain it and transport it are extremely numerous. Divided into two general layers, the one superficial and the other deep seated, they exist in all parts of the animal economy, they traverse all its regions; they wind along its surface and between the fibres of the muscles; they cover, and as it were envelope all the viscera.

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They therefore announce an important function; and the liquid which distends their conical cavities separated and contracted from space to space by valves, must serve for purposes both numerous and necessary for the support of life.

2. Notwithstanding all the interest which the knowledge of the nature of the lymph must possess for animal physics, this knowledge is as yet but very superficial or vague, or even erroneous: no author has occupied himself with it in particular; chemical science cannot yet present any analysis of this humour. From Bartholin and Rudbeck, the first anatomists who discovered these absorbent vessels towards 1650, to the last very extensive and accurate researches of Mascagni and some other moderns, every thing has been done for the knowledge of the structure, the number, the disposition, and the course of these absorbent vessels, but nothing has yet been done as to that of the lymph which they convey. Indeed we have not the means of procuring this liquid, as we have of obtaining the blood. Though at present the most of the absorbent vessels have been well described, and though the course of a great number of them are known, we are as yet ignorant of the art of extracting the lymph pure; no *lymph-letting* is performed, whereas blood-letting is performed with great facility.

3. Some circumstances of chirurgical diseases, however, afford opportunities for making experiments upon the lymph. In wounds and ulcerations

cerations of the inguinal and popliteal regions, it sometimes happens that the trunks of absorbent vessels are opened, and that the lymph flows out of them in such abundance, that the clothes and dressings are very strongly impregnated with it. I recollect having seen two such cases in an hospital in Paris; but I was then too young and too little advanced in this kind of researches to have derived the advantage from them which they might have afforded me. Similar circumstances are perhaps not so rare as might be believed; and it is to be hoped that those to whom they may hereafter present themselves, will not let them escape without availing themselves of them for the benefit of the art. Perhaps even, if we should direct our views towards this kind of researches, we might acquire the art of opening absorbent vessels at pleasure, and by this kind of lymph-letting imitate what is performed in blood-letting. There is even ground to believe that this species of operation may sometime fulfil useful indications, remedy lymphatic plethora, diminish the mass of super-abundant white and nutritive juices, evacuate this humour accumulated in the cavities: for the depletion of a large lymphatic vessel, and the vacuum by which it would be followed, must augment the force of suction and absorption in one of the regions, and consequently in the whole continuity of the absorbent system.

4. Whilst

4. Whilst I await the fulfilment of my wish, that this idea may strike deeper root in the learned and medical world, I must at least collect here what has been said concerning the nature of the lymph. Instead of taking this liquid in its own canals, and for want of the humour itself which we have not yet been able to extract from its proper reservoirs, the serum of the blood has in some respect been substituted in its place, and represented as the lymph in most works of medicine and physiology. Haller himself, though otherwise so exact, and who preferred facts to any hypotheses, has followed this method. We find it indicated in a great many places of his immortal work, and particularly in the article concerning the serum of the blood, and in the sketch of the chemical classification of the humours which precedes his history of secretion. Most of the physiologists who have written since him, and who may almost all be considered as his copiers or plagiarists, have had no other idea. Dehaen, who however has endeavoured in his works to introduce more precision into the theory of the humours and of their morbid alterations, has followed this opinion. I know only Bucquet, who, in his Course of Lectures, has combated this similitude adopted between the serum of the blood and the lymph, and who has insisted not to prove that these two liquids are not the same, for of this we have not acquired any certainty,

certainty, but to show, that as long as the lymph shall not have been particularly examined, we can have no certainty that it is of the same nature as the serum, and that we are no less authorized to suspect it to be different than to assert that it is analogous with it.

5. Haller, where he quotes the anatomical and physiological labours of Stenon, Bartholin, Drelincourt, Bellini, Wepfer, Werreyen, and Monro, and calls the lymph serum, and the serum of the blood lymph, indiscriminately with these celebrated men, ranks the latter humour amongst the gelatinous; but we soon perceive that he gives this name of *gelatinous humours* to those which I call *albuminous*, since he indicates at the same time the concrescibility by fire as their distinctive character. He therefore announces that the lymph is coagulated by heat, by the acids, by alcohol, that it is saline, slightly viscous; that it froths by agitation; that it concretes into solid flakes by the action of boiling water; that it is soluble in cold water; that it yields by distillation a fetid oil and concrete volatile salt or carbonate of ammonia; that salts are found in solution in it: in a word, he composes its history and the totality of its properties of all those which belong to the serum of the blood. He makes of it really an albuminous humour; he adds that it renders the oils miscible with water, and he proves it by the absorption of the fat effected so easily and sometimes so speedily by the lymphatic



phatic vessels. He even takes care to distinguish well from this liquor, as from the serum of the blood, the mucous humours which answer to those which I call *gelatinous*, as he assigns to these the character of not being coagulable, but on the contrary fusible by the action of heat, of being very transparent and glutinous. Senac, Quesnay, and Dehaen, had already admitted a like distinction.

6. Without denying the possibility of this identity, or at least of a very strong analogy between the lymph and the serum of the blood, which may in fact be considered as its first source, we cannot however avoid two reflections equally just and important: the one that there is wanting to the proof of this analogy an analysis of the lymph taken in its tubes, and compared with that of the serum, as Bucquet said; the other, that even admitting the serum of the blood to be the only source of the lymph, it is natural to conceive that there exist in the latter more or less considerable differences from the albumino-mucous liquor of the blood, since the latter must, during circulation by serving for several different uses, passing through different organs, furnishing several secretions, losing some of its principles, have experienced an alteration sufficiently considerable for it no longer to be capable of being considered as having exactly preserved its primitive nature and composition.

7. Were

7. Were we permitted to indulge ourselves in conjectures founded upon some facts which may render them probable, we might believe for example, that by the effects of the fixation of oxygen, of the disengagement of heat, of the loss of water, or of hydrogen, and of a portion of its carbon, effects which, having commenced in the lungs, are continued throughout the whole route which the blood takes during its circulation, the blood passes gradually into the state of fibrin; that in proportion as this takes place, the albumen which remains without this conversion becomes more oxygenated, more concrescible, more plastic, and that one of its parts disazoted, dishydrogenated, and carbonated, forms the animal mucilage or the gelatin. The lymph then, which would be in some measure the residuum of this portion of albumen converted into fibrin, which continues as such, either to constitute the blood or to form the muscles, would contain a portion of highly oxygenated albumen, and a larger quantity of gelatin. Thus the hæmatosis would terminate by a separation of the blood into three different matters: the one highly azoted, or the fibrin; the second highly oxygenated, or the very concrescible albumen; and the third highly carbonated, or the gelatin. A portion of the two last dissolved in water would form the lymph, and a portion of the fibrin deposited with the colouring matter in

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in the muscles would support their nutrition and life.

8. But though this conjecture accords well with the knowledge which we have concerning the comparative nature of the three matters which enter into the immediate composition of the blood; though we see in many chemical operations upon the animal matters a sort of partition of their primitive homogeneity into two or three different substances, it will always be merely an hypothesis till a careful analysis of the real lymph, compared with that of the serum of the blood, shall have decided upon the probable difference which exists between them, or upon the analogy which has already been supposed between these two liquids. It must never be forgotten that our knowledge of the very prompt alterability of the animal liquids renders the difference infinitely more probable than the analogy between these two liquids; and that the lymph may very well not be what I have supposed it, without on that account being in all respects similar to the serum, as the physiologists have admitted by a decision too precipitate and too little founded upon facts not to be an error.

## ARTICLE IV.

*Of the Fat, and the Sebacic Acid.*

1. THE fat is an animal oil more or less fluid and running, or at least soft in the living animals, which consequently ought to be ranked amongst the liquids. As it is almost universally diffused in all the regions of the bodies of animals, I have placed it in the first class of their immediate materials. It is lodged in small sacs formed by the cellular texture; in which it even assumes, as in a mould, the form of their interior sides. Accordingly, we almost always find the fat in kinds of lumps or pieces of flat, orbicular or irregularly square figures. When we examine it by the microscope, we see it formed of vesicles filled with a transparent humour. Wolf has compared the fats of several animals in this point of view. In dissections and when the vital heat is extinct, we find the fat more or less solid; but the softening which it undergoes between the fingers is of itself sufficient to prove that it is liquid and running in the organs of living animals; besides, many anatomists have seen it, on opening the bodies of living animals, in a real state of fluidity.

2. The fat has a sweet and faint taste, a very slight odour when it is hot, a specific weight inferior

inferior to that of water, at the top of which it floats. Its taste is sometimes a little acrid, and its smell rather strong in some kinds of animals, especially in those whose muscles are black and which naturally use violent exercise. Though its colour is in general pretty white, it however varies from the greyish white to a more or less orange-yellow, greenish or reddish colour throughout the whole scale of animals. The same is the case with its consistence, which extends from the fluidity of an oil to an unctuous softness in these beings whilst living, and from this softness to a dry and brittle density after death and after the cessation of the vital heat.

3. The fat is found abundantly diffused under the skin, where it forms immediately under the cutis a more or less thick integument. There is much of it at the surface of the muscles between the intervals of the different species of these organs and in the interstices of their fleshy fasciæ. We also meet with a remarkable quantity of it round some parts of the articulations, in the ball of the eye where it envelopes the muscles along the vessels of the neck, in the mediastinum and at the base of the heart, round the stomach and the intestines. It is especially in the vicinity of the kidneys and in the membranous duplicature of the epiploon that it is accumulated in great abundance. If there be little of it round some of the muscles which are constantly in motion, there is on the contrary a considerable

considerable proportion of it upon the large muscles of the abdomen, and on the outer part of the buttocks which it partly causes to project in the human species, whilst no animal presents this protuberance of the buttocks. It is also abundant upon the breast, round the mammary glands in women, in whom it determines the prominent, rounded and graceful form of the bosom. The folds of the great articulations also present a remarkable redundancy of it, as well as the palms of the hands, the soles of the feet, the tendinous extremities, mucous bags or capsules destined for facilitating the sliding of the tendons. There are very few animals which present any in their brain, upon the forehead, upon the cartilages of the nostrils, of the ears, round the lungs, or the penis ; it constitutes in general the twentieth part of the weight of a man. Its quantity varies according to the different animals and according to a multitude of circumstances.

4. Some anatomists have admitted particular organs for the formation of the fat. Malpighi, in describing the adipose glands, believed that there existed also vessels for conveying it into the different parts ; but neither the one nor the other of these organs have been seen and confirmed since him. It is generally believed, with Haller, that the fat is separated from the blood in the arteries ; that being formed in these vessels it is carried by its specific lightness to the circumference of the sanguineous cylinder which distends

distends the arteries, and pushed through small orifices, with which their sides are supposed to be perforated, into the cells of the mucous texture. In order to prove this opinion, Haller lays great stress upon the phenomena of injections which exude through all the lateral points of the arteries; he adduces that the fat frequently exhibits points and a red tinge of blood extravasated through the sides of arteries after animals have been violently hunted; that Morgagni has seen fat run in drops from divided vessels; that Malphigi asserts that he has seen it in the arterial and circulating blood of frogs, and that Glisson and Ruyfch have discovered it in the blood of scorbutic patients. Rest, abundant nutrition, diminution of the secretions, and especially of perspiration, the debility and relaxation which follows hæmorrhages, castration, are the circumstances which favour its formation. A marked disoxygenation in the blood is its primitive source, according to the principles of the French pneumatic chemistry, so well applied by Dr. Beddoes. We see birds become fat during a fog of some hours continuance, (qu.) especially ortolans, robin red-breasts, thrushes, &c. The absorbent vessels suck it up and cause it quickly to disappear in the animals that sleep during the winter, or in fibrile diseases, in great suppurations, during violent exercise, in consequence of the use of acrid food the abuse of vinous or spirituous liquors, mercurial frictions, &c.

5. The chemical nature of fat was not known till within a few years past. Olaus Borrichius was the first who paid particular attention in the seventeenth century, to the acrid and strong smoke which is disengaged from this substance when strongly heated, and described the bad effects which it produces upon persons who expose themselves to it. In 1740, Grutsmacher, from the action of the powerful acids upon the vegetable oils, considered fat as an oil thickened by an acid. His opinion was followed by all the chemists down to our own time. Grutsmacher occupied himself with this acid of fat in 1748. Rhades, having been engaged in the investigation of animal matters by the instances of the celebrated Haller gave some details relative to this humour in a Treatise published at Gottengen in 1753. Knape considered this acid when rectified as very strong and forming a particular species. A year after the investigations of Rhades, Leyner gave an account of a series of experiments upon the acid of fat, upon which he published a particular dissertation. However, notwithstanding these preliminary labours, D'Aumont did not hesitate to deny, in the first edition of the Encyclopedia, the presence of an acid in the distillation of fat. Haller re-established the truth in the supplements which he added some years afterwards to the medical articles of that work. Crell, in 1779, published a long Dissertation and an extensive series of experiments upon fat and its acid ; he showed



how to extract and purify it; he described its distinctive properties and its saline combinations. Since him, all the chemists have confirmed as well as extended the results of Crell upon the acid extracted from fat. Maret, in the academical courses at Dijon, repeated his experiments and added some facts to them. Citizen Guyton has published an accurate history of them in the first volume of the *Encyclopédie methodique*, or that in which the order of the subjects is followed; he there especially maintains the existence of this acid ready formed in the fats. Citizen Berthollet has proved the presence of oxygen in them, and has ably described the mode of their action upon the metallic oxides. I have also occupied myself with the chemical properties of this animal compound; I have found that the sebacic acid does not exist in it ready formed, but that it requires the decomposing action of fire in order to obtain it; I have shown that the nitric acid oxygenates fat and renders it capable of acting in a very remarkable manner upon the animal economy. It is since this period that it has been employed with success in the itch, in inveterate herpetic eruptions, cutaneous syphilitic symptoms, &c. I have discovered the possibility of explaining its formation, its fusion, &c. by the chemical attractions and the state of the blood in living animals: finally, I have determined the difference of some species of fat.

6. The

6. The first experiment, or first process which is practised upon fat, consists in its purification. It is known that this humour, such as it is, extracted from the body of animals, is mixed with cellular texture and with lymphatic vessels, with blood and with gelatinous mucilage ; that it is very susceptible of alteration : In order to purify and preserve it, it is cut into small fragments ; the most apparent and the largest membranes and vessels are separated from it ; it is carefully washed, with much compression, in a large quantity of water ; it is even triturated with water in a mortar ; it is melted in a vessel of porcelain or pottery with a small quantity of water ; this is suffered to be dissipated till the crackling noise which indicates its passage through the fused fat and its evaporation into the air is no longer heard ; it is carefully scummed in order to separate from it portions of the solid parts which may remain in it ; it is poured into a cold and new vessel, in which it becomes fixed in a white, granulated and crystalline mass, very smooth, soft, and fusible between the fingers, which keeps for a great length of time. This operation is principally performed in the laboratories of Pharmacy and the perfumers' work-shops with the fat of pork, which is in this state called lard or *axungia*. The fat thus purified is more opaque, less dense, and much whiter than in its natural state : it retains between its molecules a certain quantity of water which gives it these new characters.

7. Fat exposed to a mild fire is liquified, becomes transparent, and fixes into small, close and granulated crystals by cooling. Its fusion takes place between forty and seventy degrees of the centigradal thermometer, according to the different varieties of this animal matter. It may be melted in *balneo mariæ*, in order to avoid its alteration when we wish only to effect its fusion. Heated in contact with the air beyond the heat requisite for fusing it, it quickly acquires a temperature superior to that of boiling water; it becomes capable of baking and drying the vegetable and animal matters that are immersed in it, which are drawn out of it hardened at their surface and deprived of water. Soon afterwards there arises from it acrid and pungent vapours, which excite a discharge of tears, and irritate the fauces. This smoke inflames, and the fat continues to burn till it is reduced into coal. We see by this that it does not burn till after it has been volatilized, and that it is in order to reduce it into vapour that, when it is employed for lamps, a wick is used for the purpose of conveying into the air the part which has been reduced to vapour.

Fat distilled on the water-bath affords a certain quantity of water of a faint smell, in which the different re-agents produce no alteration, and which nevertheless becomes turbid, deposits flakes, and acquires a fetid odour when it is kept. This water, however, presents a less sensible alteration than most of the other animal substances;

substances ; it becomes less ammoniacal ; and it is in general a very marked character of this species of humour ; that it affords much less of the latter product than all the other animal compounds ; which has induced chemists hitherto to say that it was an almost vegetable matter, or which passed almost without change from the vegetable aliment into the body of animals. The water which is obtained in this distillation of fat on the water-bath was not entirely contained in this humour ; a part is formed at the expense of the hydrogen and of the oxygen which it contains : on which account, after this mode of action of the fire, the fat is perceptibly drier, and of a fawn-yellow or brownish colour, which announces its commenced decomposition and the precipitation of the carbon.

8. When we distil fat in a retort, we effect its decomposition in a much more complete manner. This operation has long been performed in the laboratories of chemistry : nevertheless its real mechanism and remarkable phenomena have hitherto been unknown. It has been observed, that in this distillation the fat passed almost entire into the receiver when it was heated a little strongly ; but there was however disengaged a small quantity of very acid water, an elastic fluid, which Hales reckons to amount to eighteen times the volume of the fat, which was believed to be air, and that there remained a coally mark in the retort. It has

has been seen, that by repeated distillations of the sublimed fat, there was each time obtained from it a portion of acid water, an oil which gradually became attenuated, a portion of air, and a light layer of coal: it was thence concluded that by repeating this operation the fat would be converted into the state of water and of air. It results from these facts, which are now better understood, that it is into water and carbonic acid, besides a small quantity of ammonia, that the fat is reduced completely, and in its last analysis; but that in order to arrive at this complete decomposition, it is necessary to add to this matter when heated a large quantity of oxygen; that it is on this account that the operation advances much faster in a large vessel than in a small one, or that we are obliged to repeat the distillation a great number of times in succession; finally, that this decomposition resembles, though in another mode and with other phenomena, the combustion of the fat in open vessels; that when this is performed with care, we have only water and carbonic acid as products; that when it is effected only in part we obtain from it, as in distillation, an acid vapour, a portion of oil not decomposed, but merely volatilized, and a coally, or fungiform concretion of coal, which collects upon the wick, and present a new obstacle to this phenomenon; that thus the products of the distillation of the fat in the retort, the phlegm, the sebacic acid, the gases,

gases, the more or less liquid oil, are kinds of compounds intermediate between this body and the water, and carbonic acid, which are the ultimate terms of its decomposition; that their proportion must vary according to the force of the decomposition that is effected, according to the temperature that is employed, the size of the vessels, the quantity of air which they contain, the manner in which the fire is managed, &c.

9. These general notions serve to enable us also to conceive and explain what the different chemists have written concerning the distillation of fat. Neuman, one of the first who has well described this operation, distilled comparatively the fats of the bullock, the sheep, the hog, and the goose: he employed 1152 parts (grains) or two ounces of each of these fats. That of the bullock gave him sixty parts of phlegm or empyreumatic and acrid liquor, of which he has not however indicated the acid nature, 852 parts of oil, and eighteen of coal. From the fat of sheep he obtained ninety parts of phlegm, 854 of oil, and 16 of coal; from that of the hog, 70 parts of phlegm and 880 of oil; and from the fat of the goose, 60 parts of empyreumatic water, 890 of acrid oil, and 10 of coal. He considered this coal as earth: he took no account of the elastic fluids, and he did not know the sebatic acid. Hoffmann believed that the product of the distillation of fat was alkaline, as it turned copper  
4 blue.

blue. Segner obtained from four ounces of human fat, heated to 600 degrees of Fahrenheit's thermometer, or 270 of Reaumur, 100 drops of phlegm, the acidity of which he has indicated, as well as Vogel: he has observed that this product reddened the blue colour of violets, that its strong odour was obnoxious to the brain: that there remained in the retort, after he had obtained it, a concrete and blackish oil.

Crell performed the distillation of the human fat in a more careful manner: twenty-eight ounces, heated in a glass retort with the sand-bath, yielded, after having melted at the 115th degree of Reaumur's thermometer, an insipid phlegm; at 220 degrees, an inflation took place, which did not appear in the fat of the bullock; there were disengaged two liquids, a brown and liquid oil upon a water of a gold-yellow colour, besides an oil fixed at the bottom of this water. The operation lasted twenty-one hours: all the products had a strong smell. By distilling them over again, he obtained twenty ounces, five drachms, forty grains of fluid oil; three ounces, three drachms, thirty grains of acid phlegm; three ounces, one drachm, forty grains of brilliant coal, five drachms, ten grains loss.

We easily perceive, in the differences of the proportions between these different analyses, the truth of what I have advanced concerning the varieties of the mode of operating, of the temperature,

perature, of the form and size of the vessels, concerning the rapidity with which the heat is applied, the repetition of the distillations, &c.

10. Fat kept in the air becomes the more altered in it the more multiplied the points of contact between them are, and the hotter the atmosphere is; it acquires a yellow and sometimes an orange colour; it assumes a pungent odour, which is known by the name of a *rancid smell*, with an acrid and manifestly sour taste. This kind of rancidity, which is owing to the development of an acid, supposes also the fixation of a portion of oxygen; it appears that it proceeds from a fermentation which establishes itself in the gelatinous substance, which accompanies even the purified fat, which reacts upon the adipose substance itself, which develops in the latter sebacic acid, and perhaps a small quantity of acetic acid in the first. The water in which rancid fat is washed acquires an acrid taste, and the property of reddening the blue vegetable colours. Mr. Poerner employed this liquid in order to purify it. Alcohol equally possesses this property, according to Citizen Machy. However, both of these agents dissolve a part of the fat at the same time with its acid, and the fat, though well washed, retains a portion of the latter. These observations already prove that the sebacic acid, developed in the rancidness of the fat, was not contained ready formed in this substance, but that it is formed by the fermentation itself  
which



which it has undergone. However little rancid the fat may be, we see that it acquires properties very different from those which it possessed previous to this rancidity, and which it must however have in part, at least, if it naturally contained sebacic acid ready formed.

11. Fat mixes very well with sulphur by simple trituration; it dissolves it with the aid of fusion, and assumes a pretty strong consistence by this union, which forms the sulphurated ointment. When we heat this sulphurated fat, we do not obtain from it any sublimed fat, but a large quantity of sulphurated hydrogen gas and of sulphureous acid, because a high temperature, by favouring the decomposition of the fat, transfers a portion of its oxygen to the sulphur, which it burns in part, and of its hydrogen to the same body which it carries off in the gaseous form.

The case is the same with phosphorus, which is dissolved very easily in the heat by melted fat. It is difficult to separate the phosphorus from this combination: it is, however, not so much fixed in it as the sulphur; but it is also disengaged from it by the action of heat in the state of phosphorated hydrogen gas. In performing this experiment, it is necessary to employ precautions in order to prevent the detonation and sudden inflammation which may be produced by the phosphorated compound.

Fat acts even in the cold upon some metals, the oxidation of which it effects, or at least favours,

favours, when it is triturated with these bodies reduced into small particles, and in contact with the air. This effect is particularly perceptible in the preparation of the mercurial ointment, which consists in triturating running mercury with hog's lard. We see this metal gradually lose its metallic form and liquidity, and the fat acquire a black colour. Though in this extinction it was at first thought that the mercury was only divided, as we always see metallic globules in the best prepared ointment, it is certain that it is a real black oxidation of the metal, because it takes place much more speedily when we add to the fat red oxide of mercury, super-oxygenated muriate of mercury, or when, instead of simple lard, we take oxygenated fat, as I shall indicate hereafter, when we aid this extinction by highly oxygenated animal matters, such as saliva. The fat acts in the same manner upon copper, which it very quickly converts into green oxide. This phenomenon is very perceptible with wax, which indeed is one of the most highly oxygenated adipose substances.

12. Water does not dissolve fat, and when we employ it in order to wash and purify it, it is only in order to separate from the blood and other soluble matters which it contains. When fat is boiled in water it melts, and the aqueous liquor then dissolves the membranous laminæ, and the cellular texture which are interposed in it; so that if the water be in small quantity,  
and

and we afterwards suffer it to cool, it concretes into a jelly. I have already said, that a portion of this liquid is interposed between the molecules of the fat : so that after the cooling and condensation of the latter, it is in a granulated form, more light, white, and opaque than it was before. It is necessary to heat it afterwards for a long time, in order to separate from it this portion of water, which escapes with a crackling noise till the last particle. Another effect is produced by the water when the fat is boiling and violently heated, when it is on the point of being inflamed, and especially when it is so already. Water thrown upon fat thus heated frequently produces a considerable explosion, and greatly augments its inflammation, which is owing to a real decomposition of the water effected by the red-hot carbon, and the rapid disengagement of the carbonic acid, and of the hydrogen gas, which are the product of this decomposition. On this account water, so far from being able to stop the burning of inflamed oils and fats, only gives greater activity to the combustion, and augments its ravages.

13. Fat acts, with the aid of heat, upon all the metallic oxides, and reduces them at first by becoming itself oxygenated, and afterwards by being decomposed. This effect is observed in the preparation of ointments and plasters. It is the same as that which I have described in the history of the oils. Many metallic oxides,

oxides, especially those of lead, copper, and iron, are soluble in hot fat; they give it consistence and heat; they form with it kinds of insoluble soaps; it is therefore dangerous to melt fat in earthen vessels glazed with the oxides of lead and of copper.

The powerful acids, and especially the sulphuric and the nitric, act in a very remarkable manner upon fat, whilst the weak and little decomposable acids, or those which yield their oxygen with difficulty, do not cause it to undergo any alteration.

The concentrated sulphuric acid turns fat brown, and reduces it to coal in a perceptible manner in the cold: its action stops when it has formed in it a sufficient quantity of water to be saturated with it. In the heat it goes much farther; there are disengaged sulphurous acid gas, carbonic acid gas, and sulphurated hydrogen gas. The fat is afterwards in a great measure decomposed, and there remains of it only a small black portion having little consistence.

The nitric acid acts but very little in the cold upon the adipose compound. In the heat, at the temperature, at which the fat melts, nitric acid, at 32 degrees of the aërometer, is decomposed, yields oxygen to it, gives it an orange-yellow colour; there is disengaged a small quantity of nitrous gas, and azotic gas; it is in this manner that we obtain the oxygenated ointment, which I first proposed several years ago, to be substituted instead of the unguentum  
1 citrinum,

*citrinum*, and which Citizen Alyon has since found so useful in the itch, in old herpetic eruptions, and in venereal affections of the skin. He prepares it by taking fifteen parts of fat, and one part of the acid indicated, by causing them to act at a mild heat till an ebullition takes place, by withdrawing the mixture from the fire, and by agitating it considerably whilst it is cooling. There may be many degrees of the oxygenation of the fat, according to the form and the quantity of the acid which is employed. If we employ three or four parts of nitrous acid to one of fat, and heat it strongly, we decompose these two bodies; the fat becomes sensibly brown, sebatic acid and a little oxalic acid are formed, whilst much nitrous gas and carbonic acid are disengaged, without mentioning the water which is disengaged at the same time. Amongst the different oxidations which the fat is made to undergo by treating it by this acid, of different strengths, at different temperatures, and in varied doses, there is one which approaches so near to the dryness of wax, that there is reason to hope we shall at some future period, be able to give it this character in our manufactures. The fat oxygenated to the state of ointment or pomatum extinguishes mercury five times faster than natural fat, and may serve with great advantage for the preparation of the *unguentum citrinum*: it is also susceptible of quickly oxidizing copper, which it dissolves with the aid of heat, and with which it soon forms a  
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fort of brown ointment; it is soluble in alcohol, &c. We may oxygenate fat by means of the oxygenated muriatic acid.

14. The caustic alkalis have a very strong action upon fat; they easily reduce it to the saponaceous state. This kind of animal soap may serve for all the purposes of economy, and it is manufactured of this kind in some countries. Ammonia does not exert any such action upon the adipose compound. Lime, barites, and strontian, combine with it, and constitute earthy, hard, solid, and insoluble soaps. These compositions are sometimes employed in the fabrication of mortars or cements, and they give them a considerable solidity, and the property of receiving a soft and unctuous polish. The soaps of fat, when burned by a violent fire, are reduced to coal and afford alkaline and earthy sebates, which some modern chemists have believed to be all formed in the original soaps, but which are really formed only by the high temperature which burn and decomposes the fat. I shall soon speak of them again in treating of the sebatic acid. The salts have no action that is known upon fat; the muriate of soda preserves it, and keeps it for a considerable length of time from becoming rancid.

15. The metallic salts and solutions exercise in the heat upon melted fat, an action which has long been known in the laboratories of pharmacy: where several compositions of ointments or plasters, are prepared with these matters: it is especially exemplified with the nitrate of mercury

mercury in solution. When we pour this solution into melted fat, and agitate the liquid, there is suddenly formed a yellow precipitate, and the mixture, as it cools, assumes a solid consistence, preserving its colour; on which account it has been called the citron-ointment. The oxide of mercury in this composition quits the nitric acid, and passes into the state of yellow oxide; the fat is oxygenated by the acid, and itself assumes a similar tinge. We see azotic gas disengaged in small bubbles. All the metallic nitrates, and most of the salts and acid solutions of the metals, present either a solution or a decomposition by melted fat. Several of them even unite well with it in the cold and by simple trituration. This kind of combination which as yet is little known, and the reciprocal action which accompanies it, deserve to engage the attention of the chemists, and must afford, by new researches, useful matters to the arts, as well as new results to the theory of the science.

16. Fat combines with a great number of vegetable and animal substances: it easily dissolves the extracts, the green colouring parts, the balsams, the resins, and the gum-resins, as we see in the preparation of a multitude of ointments and plaisters; it obstinately retains all the odorous materials of those bodies, as is proved in the art of perfumery; it stops the alteration of which these substances are susceptible and preserves them for a great length of time;

time; it unites with elastic resin though with difficulty. Alcohol has no action upon it, at least unless it be rancid or oxygenated; however, some species of adipose substances, amongst those which naturally contain the most oxygen are capable of dissolving in it. The mucilages combine with melted fat, and communicate to it that kind of softness and unctuousity which characterizes some ointments. The gums triturated with fat render it soluble, or at least capable of remaining suspended in water. It is capable of uniting by fusion with the oils, to which it communicates a part of its consistence. Tannin appears also to be susceptible of combining with fat, though this kind of combination has not yet been spoken of. Finally, the albuminous animal liquors unite also with it by long trituration, and it is through their mediation that the fat is taken up again by the absorbent vessels and carried back into the circulation. Haller has observed that some purulent humours, which are only a compound analogous to those which I here indicate, have the fatty character and inflame when they are heated.

17. I have announced, in several of the preceding articles, that fat affords, by its decomposition by fire, a particular acid, which has been called *sebacic acid*, as it is obtained in considerable abundance from tallow. This product deserves a particular description. Crell has occupied himself the most with this subject of all the chemists. After having found that



it was constantly disengaged during the decomposition of fats by fire, he endeavoured to find the means of purifying it; but he met with great difficulty to separate the oil which accompanies it. Having employed distillation with the view to concentrate it, he obtained a very acid water, and was convinced that it was more volatile than this liquid. He saturated the acid product of fat with pot-ash, evaporated the liquor to dryness, and heated the residuum in a crucible till it afforded no more smoke; and till it dissolved without colour, by precipitating carbon during its solution in water. This second solution being evaporated afforded him a foliated salt which he distilled with half its weight of sulphuric acid, and he thus obtained a fuming acrid acid, in the proportion of one-twentieth part of the salt employed. When this salt had not been sufficiently calcined it gave him by the sulphuric acid an oily liquid of a gold-yellow colour mixed with the acid liquid. He employed an ordinary copper alembic for distilling the fat and obtaining from it the acid liquid, as well as the fluid oil; but this process did not answer his purpose; the acid retained copper, and the tinning of the capital was melted; he therefore endeavoured to find another process than the distillation and the saturation of the product of the fat by the fixed alkali in order to procure the sebacic acid. The following is that which he adopted after many attempts.

18. Persuaded, with all the chemists, and especially Cartheuser, Macquer, &c. that the sebatic acid existed ready formed in fat, he proposed to fix it by means of the alkalis immediately and independent of distillation. He made a soap of fat with pot-ash, of which he mixed ten pounds in a gelatinous state with 22 ounces of dissolved alum; by separating the liquor from the precipitate formed by the insoluble aluminous soap, and evaporating it, he extracted from it twenty one ounces of sebate of pot-ash, mixed with sulphate of the same base. It was from this salt distilled with the sulphuric acid that he extracted the sebatic acid; he rectified it upon a quarter of the salt preserved for this purpose. He assured himself that this rectified acid contained no sulphuric acid by trying it with the acetite of lead; the precipitate which he obtained ought to dissolve entirely in vinegar if it was only sebate of lead, and not dissolve intirely in it if it were mixed with sulphate of lead.

Citizen Guyton has described another more easy and more simple means for obtaining the sebatic acid. This means consists in treating the fat with quick lime, by mixing this caustic earth in powder with melted fat; the mixture is left to cool, the soap is washed with a large quantity of water, the ley is filtrated and evaporated; the brown calcareous sebate which is the product is strongly calcined in a crucible, then lixiviated, the solution filtrated, the

super-abundant lime is separated from it by the carbonic acid, and it is afterwards evaporated by distilling the white and pure calcareous sebate which it affords with sulphuric acid, pure sebatic acid is obtained. It appears evident to me, that there, as in all the proceeding cases, the sebatic acid is the product of the great alteration which the fat suffers from the fire, that it is not contained ready formed in the fat, and that the calcinations to which the alkalis and the lime, as well as the fat, are subjected, when under pretence of purifying the salt it is very briskly heated, are the true causes and at the same time the proofs of the formation of the sebatic acid. In my opinion it is neither a sebate of pot-ash nor a sebate of lime: it is not a salt but a real adipose soap which is heated, and which then leaving the animal oil to be decomposed, presents the earthy or alkaline substance to absorb and fix the portion of sebatic acid which is formed. No fact proves that pure fat contains this acid; it is only by a conjectural theory that it is admitted, whilst on the contrary, every thing proves that in order to prepare it, it is necessary to decompose the fat and combine its constituent principles in another order.

19. Crell extracted sebatic acid to the amount of a little less than one fourth of the fat, by treating it according to the process that has been described. By examining this acid by different means, he began to imagine that it was the same

as themuriatic, because it had given him with soda a salt fusible without decomposition by fire, and it acts upon gold with the aid of the nitric acid, precipitates the nitrate of silver, sublimes with mercury, and its solution is not decomposed by the muriate of soda, and because its combination with antimony is precipitated by water. But Citizen Guyton on comparing this sebatic acid with the muriatic acid under other relations, has found more differences than resemblances between them ; he has besides judiciously observed, that a single chemical property constitutes a sufficient difference between them to prevent their ever being confounded together. According to him, the sebatic acid combined with soda crystallizes in needles, not in cubes like the muriate of soda ; it forms no deliquescent salt with iron ; it attacks running mercury ; it precipitates the oxygenated muriate of mercury, as well as the muriate of soda, the base of which it retains whilst it disengages its acid by distillation ; lastly, alum is not decomposed by the sebate of lime, which is also one of the most distinguishing characters of this acid. According to these principal differences, Citizen Guyton does not hesitate to consider it as a particular acid different from all those that are hitherto known.

20. The sebatic acid appears to be formed generally by the decomposition of all the oily bodies, since Mr. Crell obtained it by distilling butter of Cacao ; however it is more easily  
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and more abundantly produced by all the fats; thus the German chemist whom I have mentioned has extracted it especially from spermaceti. Though the intimate nature of the sebatic acid, has not yet been determined, what we know of its formation permit us to suspect that it is not, like the Prussic and zoonic acids, a real animal product, or compound of a triple radical of hydrogen, carbon and azote, all united with oxygen. Of whatever nature it may be, the following are properties which distinguish and characterize it. It has an acrid suffocating odour, which irritates the eyes, the nostrils and the throat, by which it is easily recognizable. It exhales a white vapour or smoke when it is well concentrated; it resembles in its consistence and aspect an oily liquor, whence its origin is rendered apparent to the eye. It strongly reddens the tincture of turnsole, and perceptibly even that of violets. It is very volatile, assumes a reddish colour by the action of fire, and leaves at each distillation employed for rectifying it, a brown liquid, or a coally trace when the operation is carried on to dryness. It is entirely decomposed in a red hot tube, and converted into water, carbonic acid, carbonated hydrogen gas and coal.

21. Its combinations with the alkaline and earthy bases, or the sebases, have traits of resemblance with the acetites according to Bergman; Citizen Guyton however observes, that they are more fixed in the fire and less alterable

alterable by the air. The species of these salts have not yet been well described; we only know that most of them are crystallizable in laminæ, considerably soluble, decomposable by the sulphuric acid; it also appears that the order of the attractions of the sebatic acid for the bases, presents successively barites, pot-ash, soda, strontian, lime, magnesia, glucine, alumine and zircon, like most of the powerful acids, especially the sulphuric, nitric and muriatic. Some remarkable facts have been collected relative to the attractions of several of the sebrates. The solution of sebate of lime does not render that of alum turbid, which proceeds from the weak attraction of the sebatic acid for alumine. This acid, distilled with the alkaline sulphates, disengages from them sulphureous acid whilst it becomes decomposed. It precipitates the solution of tartrate of pot-ash in tartareous acidule. It decomposes the nitrate and the acetite of pot-ash by distillation, but it does not attack the muriate of soda. It appears to be capable of attacking glass and dissolving a part of it, as it deprives the vessels in which it is distilled of their polish, and afterwards deposits by digestion siliceous earth. The same effect has been seen in the pyromucous acids.

22. The sebatic acid exerts a sufficiently marked action upon many metallic substances. Distilled upon the arsenious acid it reduces it into metal, as is also done by the entire oil and fat.

fat. It does not attack either cobalt, bismuth or nickel, even by long continued digestion. It precipitates the nitro-muriatic solution of antimony, which in fact is decomposed by water alone in very large quantity. It combines with mercury and silver, when it is brought to act upon these two bodies in the metallic state. The sebate of silver is precipitated by the muriatic acids, whereas the sebatic acid decomposes the nitrates of mercury and of silver, the sulphate of the latter, and even precipitates the solution of oxygenated muriate of mercury in a white powder. It equally precipitates the nitrate and acetate of lead, but not the sulphates and nitrates of zinc, of iron and of copper. It attacks gold very feebly, but it dissolves it very well when it is combined with the nitric acid. This is one of the facts which chiefly led Mr. Crell to infer a great analogy between this acid and the muriatic. Combined with the oxide of gold, the sebatic acid forms a crystallizable salt, as well as with the oxide of platina; it precipitates both from their nitro-muriatic solutions.

The German chemist, disposed according to all his experiments, to rank the sebatic acid amongst the most powerful of these bodies, announces that it acts even upon the oils, which appears to depend upon its oily nature, and that he has succeeded in obtaining ether by treating alcohol with this acid.

23. I have described all the known chemical properties

properties of fat in general; I must now give an account of the differences which it presents, as well with respect to the different regions which it occupies in the same animal, as with respect to the age of the animal, the different orders of animals, and lastly, in its morbid alterations.

The variety of the characters which fat presents, according to the different regions in which it is considered, is a fact well known to anatomists. It is more solid under the skin and in the vicinity of the kidneys; it is less so, and it even runs like an oil, between the muscular fibres, or in the vicinity of the moveable viscera, such as the heart, the stomach and the intestines. It has a granulated character round the articulations, and in the interior of the cortical capsules. Haller has found it almost as hard as a calculus, or what is so improperly called a *stone of the bladder*, within the leg and along the internal osseous surface of the tibia.

24. Age causes the fat to vary very sensibly. Haller found none of it in the epiploon of a foetus of four months. According to Ruysch and Diemerbroeck, instead of real fat, there is only a kind of tremulous and gluey jelly under the skin of the foetus; afterwards there is formed a small quantity of granulated fat. This humour augments rapidly after birth; in the first year of life the human body is extremely fat; the fat under the skin is for a long time white; it grows yellow with age: it is extremely



tremely soft in the female sex. . At the age of forty years, its quantity exceeds that which it has at any other period of life. . This period is that of a real adipose cachexy. At the commencement of old age it melts, and suffers the skin which till then it had supported in a state of tension, to collapse as it were into a faded and wrinkled condition. The small quantity of fat which remains in old men is hard, consistent, of a deep yellow colour, sometimes approaching to a brown. The same adipose phases take place in animals as in man: they however vary with them according to their nature, the state of their blood, and the mode of their respiration.

25. The fat of the mammalia in general does not differ much from that of the human species. It has been observed that in the frugivorous and herbivorous animals it is more firm and more solid than in the carnivorous. It is to the first that the lard and tallow particularly belong. Spermaceti is a kind of fat which is extracted from the head and the spinal canal of the cacholot, and which is characterized by a dry and friable adipoceros consistence, by a crystalline, lamellated and brilliant form, by its fusibility inferior to that of ordinary fat, and by its solubility in alcohol. Of this I shall speak more hereafter in detail. I here consider it in general, because this fatty substance is found in many other animal matters besides the head of that species of whale.

The fat of birds is fine, mild, unctuous, and very fusible. In fishes it is almost fluid or oily: it deposits adipocire.

It exists in insects, worms, and the testacea; in these it especially accompanies the viscera of the abdomen, where it is placed in small lumps: it is also found, though more rarely, under their skin.

26. Diseases have an influence upon the fat; it is itself sometimes the cause of maladies. Its abundance constitutes a morbid affection; it has been known to augment the average weight of a man, which amounts to 80 kilogrammes, to 300. It sometimes presses the heart, and retards and even stops its motion; it obtunds the nervous sensibility; it disorganizes the muscles; sometimes their fibres are found converted into fat; it melts in most diseases, and seems to serve as nourishment during the torpid state of men and animals: thus the dormouse, the marmot, &c. go into their holes very fat, and come out very meagre after the hibernation. After diseases, especially of the febrile kind, man is extremely meagre; much time is not required for the fat to be formed again. Some small birds become extremely fat during a single night when there is much fog. It assumes a yellow or green colour from the admixture of bile, which appears to have much relation with fat. It is sometimes seen to flow off with the excrements in diseases. When the external part of the body of animals is

is made to grow lean by extreme heat, it is observed that their liver increases considerably in size. We shall soon see that this viscus is in fact of an adipose nature.

27. Fat fulfils a great number of uses in the life of animals; it maintains the heat of the parts by preventing the caloric, of which it is a bad conductor, to be disengaged outwardly; it is known that fat persons are less sensible to cold than lean ones. Galen mentions a person who always felt cold in the abdomen after having lost a part of the epiploon by a disease. Macquer thought that it serves to absorb the super-abundant acids of the body of animals; but he founded this idea upon the concrete state of the fat, which he believed to be owing to a combination of acid, and it is now known to be an error. This substance appears rather to absorb the super-abundance of hydrogen, and to be formed when the oxygenation is too little considerable. By its unctuous quality, fat facilitates the sliding of the parts upon one another; it prevents the fibres from being glued together. It determines the rounded, graceful, and soft forms of several parts: it distends and supports the skin, at the same time imparting whiteness to it; it fills up vacuities and intervals between many fibres, textures, or organs. It renders the bones flexible and pliant; it passes from one part into another with much facility; it is absorbed by the lymph, which renders it soluble; it in part nourishes animals,  
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who thus support themselves upon their own substance at their own expense.

28. Fat is employed for a great number of economical uses. It not only serves as seasoning to a great number of aliments, to which it communicates a mild unctuous quality; but it also is itself an aliment, and has very decided advantages in cases of a too high oxygenation of the system. It may therefore be administered in medicine, not only as has hitherto been done, as a lubrefacient, emollient, relaxant, and lenitive remedy, but also as a disoxygenating medicine, or one which absorbs that super-abundance of oxygen, which manifestly, exists in inflammatory diseases.

The numerous uses are sufficiently known to which it is applied in currying leather, in facilitating the motion of machines, in plasters, in some mortars, &c. Every fat has, as is well known, its particular utilities.

#### ARTICLE V.

#### *Of the Transpiration, of Sweat, and of the Humour of the internal Cavities.*

1. THE insensible transpiration (a word which is sometimes taken for the matter which issues in the form of vapour from the surface of the skin, and sometimes for the function itself  
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by which this exhalation is effected) is one of the evacuations with which physicians have been the most occupied, and of which physiologists have not perhaps availed themselves so much as the former have done for the theory and practice of their art. There is no phenomenon in animal life which has given rise to more researches and explanations, or which has excited so much interest amongst philosophers. It was known by Hippocrates, Theophrastus Erasistratus, and Asclepiades, who called it *pneuma*, because they knew that it had the form of air. Galen has made it one of the bases of the pathological etiology. Sanctorius acquired, at the commencement of the seventeenth century, an immortal reputation by publishing the result of his long experiments upon transpiration, and the exposition of its influence upon health and diseases. His *Medicina Statica*, published in 1614, does not however contain the detail or the description of his experiments, but only aphorisms of which we do not always see the relation with the experiments themselves, as these remain unknown; but at that period natural philosophy did not exist; and too little attention was then paid to experiments for it to be thought necessary to present their detail, and an account of the manner in which they were conducted to the readers.

2. Towards the end of the same century, in 1668, Dodart, a physician, and member of the Academy

Academy of Sciences of Paris, which had just been established in 1668, communicated to it his researches upon transpiration: he contented himself, like Sanctorius, with giving results, and comparing them with those of Sanctorius, in order to determine the differences presented in this respect by the climate of Paris, situated at forty-nine degrees of latitude, compared with that of Venice, at forty-nine degrees, where Sanctorius had made his. J. Reil repeated similar experiments during ten years at Northampton, situated at fifty degrees, and he was the first who published the detailed journal of them. Bryan Robinson did the same in Ireland; G. Rye at Cork, and Linings in South Carolina, at thirty-three degrees of latitude. When we compare those labours of more than a hundred years, which have not been continued during nearly sixty years past, though this kind of research promises, especially for the last thirty years, many more important results than could have been formerly obtained, on account of the more advanced state of the science, we find unfortunately, together with some general truths, much uncertainty, contradiction, and error. Haller shows, in his great work of Physiology, that the authors of these experiments have not taken all the possible precautions, that they have neglected both the saliva and the pulmonary absorption. He reproaches Sanctorius himself, who however has acquired so much fame, and who will always deserve it in the memory of mankind,

mankind, for having first made experiments, for having first conceived the idea of measuring the quantity of the transpiration by weight, and of placing the medical theory upon a sure foundation; he reproaches him, I say, for having allowed too much to the transpiration, and for having forced the results in order to adapt them to the Galenic theory of which he was a follower.

3. In modern times I find only Lavoisier and Seguin, who, having associated together in order to examine the phenomena of transpiration, contrived to measure in particular and separate from each other, by means both ingenious and exact, that which takes place in the lungs, and that which is effected by the skin, and to compare their relative quantity. We owe to them some important results; but only in a general way. Their researches, of some hours or some days only, do not present the long series of those of Sanctorius, of Dodard, of Kiel, of G. Rye, or of Robinson, though they are far superior to them in accuracy and precision. The French philosophers have described with much care the means and the instruments which they have employed for making their experiments; and hence we may judge of the difference between them and those of the physiologists who had preceded them in this career. Most frequently Citizen Seguin himself was the subject of these experiments. The balance which he employed, the beam  
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of which was four feet and a half in length, was so accurate, that when charged with 125 pounds or  $62\frac{1}{2}$  kilogrammes on each side, it was turned by a weight of two grammes, or half a drachm (gros). He placed and inclosed his whole body in a sack of varnished silk, which having been blown up with air, had lost nothing during fifteen days. This sack was tied close above his head: it had an aperture which was accurately glued round his mouth with a mixture of turpentine and pitch. The mouth being thus open, and communicating with the atmosphere, the pulmonary transpiration passed into the air, and that of the rest of the skin collected in the sack, which let nothing escape. By weighing himself twice at certain intervals of three or four hours, he found the weight of the pulmonary perspiration in the diminution which the balance gave him; by afterwards weighing himself in the sack likewise at certain intervals, and twice in succession, he had the weight of the cutaneous transpiration by subtracting from the total loss that which he had found by the pulmonary transpiration, and always comparing the aliments and excrements with the loss in invisible effluvia. Hitherto in these experiments means were not sought for ascertaining the nature of the transpired fluid, and only the determination of its quantity was had in view. I shall show elsewhere by what ingenious machines the same modern philosophers,

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fophers, Lavoisier and Seguin, have succeeded in carefully analyzing the phenomena of respiration.

4. Though the results obtained by these different experiments have pretty considerable differences from one another, without presenting them in all their details, as Haller has done in his great work, it is necessary at least to indicate the general results. In the northern countries, and according to the experiments of G. Rye, during the three winter months, there pass out of the body 4797 ounces of perspiration, and 3937 of urine; during the three spring months, 5405 ounces of perspiration, and 3558 of urine; in the three summer months, 5719 ounces of perspiration, and 3352 of urine; finally, in the three autumnal months, 4471 of perspiration, and 3369 of urine. In a day of the winter there are, according to the same experiments, 53 ounces of perspiration, and 42 of urine; in a day of the spring, 60 ounces of perspiration, and 40 of urine; in a day of the summer, 63 ounces of perspiration, and 37 of urine; finally, in a day of the autumn, 50 ounces of perspiration, and 37 of urine.

According to the results of Keil, there are 51 ounces of perspiration, and 38 of urine, so that the latter exceeds the former.

Dodart had found that the proportion of the transpiration to that of the solid excrements, was as 7 to 1, and to all the sensible excrements  
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in general as 15 to 12. The medium quantity of perspiration in France was, according to him, an ounce an hour.

Robinson estimated, according to his experiments, that in youth the perspiration was to the urine as 1340 to 1000, and in old age as 967 to 1000.

Hartman obtained, in analogous experiments, the following result: from 80 parts (ounces) of aliments escape by perspiration 35, by urine 28, and by the solid excrements seven. According to Gorter, the proportion of these relations is such, that of 93 parts of aliment 49 pass by the skin, 36 by the urine, and eight in the solid excrements. We see, therefore, that there are differences between the results of all these experiments made in cold countries.

5. The researches upon the perspiration in warm climates present almost an equal number of uncertainties and differences, though the experiments being less numerous afford results more easy to be brought to agree with each other. We are indebted for them chiefly to Sanctorius. He made them during nearly thirty years at Venice, where the air is hot and moist. His general conclusion is that from eight pounds of food taken in twenty four hours, five are dissipated by transpiration, and only three pass off by urine and the excrements. In this it agrees with those of the preceding authors which belong to the hot season. In the excess

of the perspiration over the sensible excrements. Arbuthnot has confirmed them in the summer in England. Linings, who repeated them in South Carolina, likewise found that in summer the quantity of the perspiration exceeded that of the sensible excrements. Many moderns have questioned the results of Sanctorius, and have thought that they were manifestly carried too high. Haller concludes, from all the experiments made by the different philosophers who have been quoted, compared with each other, that it is doubtful whether the perspiration exceed in quantity that of the urine, if we take the average of all the results which they have obtained ; and that they all differ especially from those of Sanctorius by much smaller quantities.

6. We shall see by the results which we owe to the last experiments of Lavoisier and Seguin, that they have frequently observed phenomena analogous to those already indicated : but that they have also seen some that are new and different. The following are the inferences which they have obtained from their researches.

*a.* Every four and twenty hours the body returns to the same weight when the subject is in health and when he is not in the progress of growing fat.

*b.* Bad digestion retards perspiration. He increases in weight during four days ; and on the fifth he generally returns to the primitive weight

weight. Sometimes the equilibrium is re-established rather by the augmentation of the excrements than by that of the perspiration.

c. Drink only, and not the solid aliments, increases perspiration.

d. The perspiration is at it its *minimum* during meals and immediately after them: it attains its *maximum* during digestion.

e. The maximum is 32 grains a minute, or 25 hectogrammes in twenty four hours; the minimum is 11 grains a minute.

f. The perspiration is in the compound ratio of the force of the exhaling vessels and of the dissolvent quality of the air.

g. The pulmonary perspiration is more considerable, relatively to the surface of the lungs than the cutaneous perspiration is in proportion to the surface of the skin. It is still more considerable in the winter, on account of the necessity of keeping up the temperature of the body at thirty two centigrade degrees.

7. Though the proportion of the perspiration is one of the most important objects to Physiology and medicine, there is a second which is also of importance and belongs more to the province of Chemistry; namely, the knowledge of the matter which issues in this manner out of the pores of the skin. But few researches have hitherto been made upon this subject. and it is one of those with which Physiologists have least occupied themselves.

Haller

Haller considered as the materials of this evacuation the water reduced into vapour which is frequently visible. Tachenius was the first who collected it, by inclosing his arm in an oiled cloth; but he has not examined its nature. Bonnet, Bellini, Winslow convinced themselves of its emission. Lister by keeping his arm plunged in a cold glass; obtained a saline water from it. Kaw and Gorter have especially insisted upon the water which the contact of the skin deposits upon the surface of Glass, and have remarked that the air speedily dissolves it. To this first substance, this vaporized water accompanied with some salts, Haller added the electric matter, the ejection of which he thought to prove by the sparks, the smell, the decrepitation, which have so often been observed in the cloaths at the moment when they have been taken from the body, and in the frictions applied to the hairs of cats; but it is evident that he has confounded the electric effects produced by friction with a pretended electric emanation which nothing proves to take place. The same physiologist also ranked amongst the elements of the perspiration :

*a.* Fetid volatile parts which he said were the most dense and to which he attributed the traces followed by the venatory animals.

*b.* Particles of drink and aliment, proved by the smell. On this occasion he refers to the result obtained by G. Rye; namely, that from  
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two pounds and four ounces of aliment, only four ounces passed off by the excrements and two pounds by the skin.

8. The new chemical data and a more profound examination of the perspiration have led to the discovery of something more in it than what had been admitted by the illustrious Haller. It is not true that there pass off through the skin, as some moderns have thought, elastic fluids and especially carbonic acid gas; but there is reason to believe that at the surface the nearest to the skin, namely in its immediate cavities there is disengaged and burned a portion of carbon; perhaps even a certain quantity of carbonated hydrogen exhales through its pores and experiences a slow combustion. This we should especially be led to believe by observing that the skin, exposed immediately to the air, and not covered with clothes, assumes a fawn or brown colour which seems to announce the fixation of a greater quantity of carbon; perhaps even it is this phenomenon in a highly exalted state with the negroes, which colours their mucous texture and the interior surface of their epidermis. It is known that they are not born with this colour, but that it is formed, or at least grows considerably darker by the progress of life.

There is no doubt that water ready formed passes off through the skin and that it constitutes the greater part of the perspiratory vapour. Citizen Berthollet has sometimes found an acid  
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in it, and he has even discovered in it the phosphoric acid. If this acid were discharged regularly and constantly, it must necessarily accumulate upon the skin, for it is not volatile even with the aid of the vaporized water.

9. The matter of the sweat has been thought to be analogous to that of perspiration; and it has been believed that it differed from it only in not passing off in the form of vapour, and dissolving in the air much more slowly; and though some physiologists have imagined the sweat to be a different substance and even to have its particular organs, we must however admit an identity of nature between these two excrementitious humours. It is known that the sweat is a saline water, a little viscous, in which Lewenhoeck had described globules, and which has been little subjected to analysis; but which Raymond, Bohnius, Lister, and Tachenius have thought to be similar to urine. According to some experiments, Petit has found it to be alkaline and turning the colour of violets green. Frequently it has a sour smell and turns blue paper red. It has been known to stain the linen yellow, green, blue, or black; it is known that it has very various odours, but in general acrid and disagreeable; that it sometimes partakes of that of the aliments; that it is highly odorous and even fetid in animals in heat; that it is sometimes accompanied with fat, with blood, or with bile; that it thickens upon the skin, and leaves upon it a kind of yellowish or brown residuum;

residuum; that it sometimes deposits sandy concretions, or saline crystals which Haller asserts he has seen upon the skin of glass-makers; that it forms upon the skin of the horse a concrete white or yellowish stratum, which Citizen Vauquelin and myself have ascertained to be real phosphate of lime, detached and separated in small scales by the action of the curry-comb; that its quantity varies extremely from some decigrammes only to a kilogramme and a half. Cardan reckoned the quantity of sweat discharged by a patient under a course of mercury at four kilogrammes and a quarter. Continued sweat is always a severe disease, on account of the loss of substance and the debility which it occasions. It is no longer believed with Leuwenhoeck that fifteen small drops of insensible perspiration form one drop of sweat, but it is believed that the sweat is the product of the accumulation of the molecules of perspiration which the air cannot carry off.

10. All anatomists now agree with respect to the organs which exhale the perspiration. They think that it issues from the extremities of excessively numerous minute arteries which open under the skin, and which, on account of their extreme tenuity, suffer only the lightest part of the liquid which they contain to pass. They are convinced that it is not from the lymphatic vessels that it proceeds, but that the function of these is opposite to that of exhalation. It will however be observed that since Haller and the physiologists



physiologists who have followed him, in admitting that the perspiration proceeds from the cutaneous arterial extremities, suppose that these small arteries convey only a white and aqueous liquid; they actually admit a second order of vessels which terminate the arteries, and which are the real white vessels of Boerhaave. For the rest, injections violently passed through the arterial cavities, sometimes, though with difficulty, pass out through the cutaneous pores, or diffuse themselves under the epidermis; so that if these injected liquids were sufficiently attenuated, sufficiently hot, and continually pushed forward, they would actually give rise to an artificial perspiration.

11. A kind of consideration which has hitherto been almost foreign to physiologists, which had almost entirely escaped the sagacity of Sanctorius, of which the illustrious Haller himself absolutely says nothing in the long details which he gives concerning the perspiration, which Kaul, in his work upon perspiration has also passed over in silence, and which modern chemistry alone has almost totally drawn into notice, is the influence of the air in the exercise of this function. It is such that perspiration cannot take place without its contact, that it contributes to it in an immediate manner, that it determines its proportion, that it augments it, diminishes it, raises it to its maximum or depresses it to its minimum, that we ought to affirm at present, as Lavoisier and Seguin

first showed with perspicuity, that the perspiration is in the compound ratio of the velocity communicated to the transpiring fluid by the vessels which convey it to the skin, and of the power with which the air dissolves it. We recognize the existence of this solvent property of the air, when we consider with attention what passes at the extremity of the fingers; we there see, especially in the summer, small liquid drops issuing out of the pores situated at the bottom of the elliptical groves with which this region is streaked, which are soon dissipated in the air and continually renewed, in order to be afterwards taken up and evaporated by the air. The steam rising out of the lungs, from the head, from the hands when taken out of bed, and which we see elevate itself in torrents into the atmosphere, is only the transition of the liquid perspiration to the state of elastic fluid which the air soon gives it; it is necessary therefore, in order that perspiration shall take place, that the air should dissolve it in proportion as it issues out of the cutaneous pores. This solution is accompanied with a refrigeration which every one experiences, and which moderates the heat to which the body is raised under certain circumstances.

12. It must be very evident, according to this exact notion, that supposing the conditions of the perspiration to be the same with respect to the body which perspires, to the temperature, to the motion of the respiration and of the blood,

blood, and to the quantity of perspirable matter, if the solvent quality of the air should happen to vary, variations must also ensue in the exercise of this function. This datum may not only greatly contribute to elucidate the observations of Sanctorius, of Keil, of Gorter, of G. Rye, &c. but it must also introduce important modifications into the notions that have been promulgated respecting perspiration: it may even change a part of the notions that have till the present time been considered as exact, and in this point of view change the aspect of the healing art. There is wanting in this respect a series of experiments which it is very necessary to attempt at the present moment; but notwithstanding this chasm there are some certain principles which are capable of throwing a new light upon the cause and nature of diseases, which especially may destroy erroneous opinions which have long prevailed. It is evident, after what has been said, that if the air be little charged with moisture, if it be of a temperature raised a little above 15 degrees, for example, if it be frequently renewed at the surface of the skin by its agitation or its currents, it then combines all the conditions requisite to its dissolvent quality; it must then take up much water from the skin, and the perspiration must be the most accelerated and the most abundant possible. If, on the contrary, the air be hot and moist, if it be charged with water to such a degree as to precipitate a part of it, it can take up little or  
nothing

nothing from the skin and the perspiration must be considerably diminished or completely stopped. This phenomenon frequently takes place in the summer, and if it succeeds the preceding, the skin, which no longer loses any thing, becomes covered with sweat, grows soft, and the body becomes more heavy.

13. It follows from these first principles, that when the air in winter, though very low in its temperature, at 10 or 15 deg.—0, is extremely dry, dense, and agitated; in proportion as it touches the skin, it takes from it much caloric, becomes heated at its surface, and becomes a solvent of water doubly active, both on account of its dry state and of its elevation of temperature; it therefore carries away the more perspiration the more frequently it is renovated, the more swiftly it is moved. Accordingly, in a cold, dry and windy winter, this very highly dissolvent state of the air, which is perceptible even by the manner in which it evaporates and dries the earth, pavements, and surfaces of buildings, vaporizes and carries away so much water from the skin that it dries, cracks, and rises in scales; that the body suffers a great waste of substance; that on account of the necessity of reparation, the digestive powers increase rapidly in robust and healthy subjects; that the urine becomes thick and turbid; that the humours thicken and become viscid, and disposed to inflammation. Such is the source of catarrhs, defluxions from the lungs, pleurifies, inflammatory

inflammatory fevers, proceeding, as we see, from the sluggishness, thickness, and viscosity which the liquids have contracted, much more than from a suppressed perspiration, as has hitherto been so generally believed. From what has been said, we may conclude, that in dry and windy cold weather, the perspiration is the most abundant possible; that it sensibly exceeds that of the summer; and amongst the experiments that have been quoted, especially those of G. Rye, Robinson, and Gorter, we find, when we read them with attention, results favourable to the opinion which I have advanced.

14. We also see, according to this theory, which is founded upon well demonstrated facts, and upon notions more precise than those which have hitherto been followed, that the contact of cold water covering the skin must prevent the perspiration; that the bath cannot augment or maintain it, or even let any part of it subsist, except in so far as by its more or less elevated temperature, it augments the pulsations of the heart, and the force which impels the liquids toward the surface of the body; that frequently it would be either entirely checked or very much diminished in subjects immersed in a lukewarm or cold bath, or if the portion of their body which is out of the water, if the pulmonary surface did not perspire in an increasing proportion; that their body would be very much augmented in weight, if a more  
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abundant excretion of urine did not replace the water retained at the surface of the wet skin. We thus see why a covering of waxed silk applied over any part of the body becomes filled with water, and soon stops the perspiration. We also understand the utility of ventilation, which diminishes the heat and the sweat by renewing the solvent air around the body. We conceive that persons wrapped up in blankets must have a moist skin, without on that account really transpiring, because they want the contact of the air, the indispensable agent of transpiration; and when physicians advise confinement to a warm bed, and the application of blankets, in order to make patients sweat, the good which they thereby procure them is almost always the retention of the perspiratory water which the air would have carried away from them, much rather than the discharge of a larger quantity of this liquid. There is even reason to think that this mode of treatment matures catarrhs only by actually retaining the water in the body, and thus favouring the dilution of the thickened portions of liquids, and their more easy separation from the sides of the canals to which they were in a manner attached by their glutinous and tenacious thickening. It is sufficient to have announced the bases of these new truths, in order to show what productive applications they are susceptible for the knowledge of the causes of several diseases, and the investigation of the means of combating

combating them, supported by direct experiments. They will become one of the bases of the new monument which chemistry must soon raise for the art of healing.

15. Physicians have long observed a remarkable analogy and striking relation between the urine and the perspiration; they have observed that the one of these evacuations frequently supplies the place of the other, and that they are constantly in an equilibrium which is always maintained when the body is healthy and vigorous. In fact, when the perspiration is diminished or suppressed, especially by the non-dissolvent or little dissolving state of the air, the urine is discharged in greater abundance, and it seems as if there were a direct passage open between the cutaneous pores and the tubes of the kidneys. Some anatomists even admit, on account of the rapidity and magnitude of this effect, another passage than that of the kidneys for conducting the humour of the perspiration into the bladder. Some moderns think that this function is performed by the system of absorbent or lymphatic vessels, without however having yet proved their immediate communication between the skin and the bladder. But this is not the point of view under which I ought here to consider the analysis of these two evacuations; the nature alone of the liquids which form them must especially form the object of my attention. I have already remarked, that some physiologists have found a  
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real identity between the matter of perspiration and that of the urine, and that the sole difference which they have announced between them consists in the greater quantity of water which the first conveys, and the less degree of saline acrimony which characterizes it. I must here add, that some of our recent experiments confirm this idea, and that Citizen Vauquelin and myself, after having discovered a particular urinary matter, which I shall describe elsewhere by the name of *urée*, existing constantly in all the urines of the different animals which we have been hitherto able to examine, have found it again in the residuum of the transpiration of the horse after the evaporation of this humour. I shall also observe, that Citizen Berthollet has indicated a transpiration which is acid like the urine, and consequently that chemistry has the means of determining this analogy which has been announced so long ago by the experience of physicians.

16. In describing the different uses of the transpiration, physiologists enumerate the softening of the skin and of the epidermis, as also an excrementitious evacuation which carries out of the body matters, the abundance and acrimony of which might be equally prejudicial; they support the latter opinion by the origin of numerous diseases, which are generally attributed to diminished, retained, repelled, or suppressed transpiration. Galen, after Asclepiades, has strongly insisted upon this use of



transpiration, which we find was adopted in the ancient Grecian schools of medicine. Sanctorius has carried it so far as to pretend that as long as this function is in its regular state, no disease is to be apprehended. Many physicians have believed that the diminution of the perspiration in old persons was the real cause of the gout, and the rheumatic affections so common at that age.

Some philosophers, however, have called in question this use of the transpiration; they have asserted that this evacuation might be diminished, or even suppressed without injury to the individual: they have quoted the example of nations who cover their skins with grease and oil, and who, instead of suffering from this covering which intercepts the perspiration, find in it the means of augmenting their strength. Bacon even suggested that this artificial occlusion of the pores of the skin might be a means of preserving life, and retarding the effects of old age. It is true that where they quote the pretended suppression of the perspiration during the winter, without the production of disease, the advocates for this opinion have committed a great error, as it appears, on the contrary, that in the case mentioned (No. 13), this evacuation is very considerable. There is reason to believe, that in the instances quoted by these authors, other excretions of the urine, of the pulmonary transpiration, and that of the internal cavities, increase in proportion  
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as that of the skin diminishes, and supply its place.

17. Modern philosophers have added several new notions concerning the uses of the perspiration, by representing it as an abundant evaporation of water at the surface of the body: they have seen in it a means of absorbing the too great quantity of caloric that disengages itself from it, of regulating its temperature, and maintaining it at a constant term; of thus evacuating the excess of caloric which develops itself, either in the lungs by respiration, or in the circulation itself by the fixation of the oxygen which appears to be continued in it, and to follow its intimate combination. They therefore consider this function in uninterrupted relation with the respiration, and as the regulator of the animal calefaction: they thus explain how, when this calefaction is augmented by any cause, the perspiration, having suddenly become abundant, tends to moderate it, and to restore it to its original equilibrium. Perhaps the phenomena of the transpiratory function may be carried still farther, and considered as the discharge of the water which is formed in the course of the arteries by a slow but continual combustion of the hydrogen of the blood by the oxygen absorbed in respiration, as well as that which takes place in the pulmonary vesicles. This water carries away with it a part of the animal solids and fluids in the state of vapour; and by thus evacuating the

part of the organs that is too much anamalized and worn, it contributes as it were, to solicit their renovation. For the rest, these ideas deserve to be studied and supported by experiments made with more accuracy, and under the guidance of more enlarged views than those which have given celebrity to the names of Sanctorius, Dodart, Keil, B. Robinson, G. Rye, Linings, Gorter, &c.

18. There continually exudes in the internal cavities of the body, in all the hollow viscera, in the dura mater, in the ventricles of the brain, the pleura, the mediastinum, the pericardium, the peritoneum, &c. a humour which lubricates their surfaces, which the physiologists have represented as a humid vapour, an internal *halitus*, a sort of internal transpiration, the existence of which has been proved by numerous observations. Haller has made express mention of it in his great work on physiology. Borden considered it as a stream of vapour which ran through not only the internal membranous cavities, but also all the cells of the muscular texture, and he represented the body to himself as consisting of cellular balls, all open and all communicating the one with the other, only contract from space to space. But these ideas, which were ingenious in their time, must be modified by the knowledge of the lymphatic or absorbent system, and the humour of which I here speak must not be confounded with that which fills the absorbent vessels, and which

which always follows in them a determined course.

19. The humour of the interior cavities exudes from the extremities of the arteries, as is proved by injections, and nevertheless it differs from that which is exhaled by the skin; it is much less aqueous and charged with more fixed matters than the latter. We shall well comprehend the cause of this difference, when we consider that the perspiration is formed only of the substance which is capable of being volatilized and dissolved in the air, whereas the humour of the interior cavities is neither a vapour nor a gaseous solution, but a liquid which runs by the effect of the circulation and of the motion of the blood. In proportion as it thus exudes from the internal surface of the membranes which it moistens, it is re-absorbed by the orifices of the absorbent vessels, so that it never accumulates to such a degree as to distend these membranes; it always forms in them only a light mucous covering which separates from it and lubricates their surfaces, whilst the animal is in health and vigour.

20. We may distinguish the viscous, mucilaginous, gluey state of this liquid, by introducing the finger into these internal cavities and upon the membranous surfaces, either of living or of dead animals. We perceive, by the mere sense of touch, that this humour is really an albuminous and gelatinous solution analogous to serum. It is only by these simple experiments that we can estimate

estimate its nature; for it is not sufficiently abundant in the natural and healthy state to be capable of being collected and examined by chemical processes. Sometimes however it happens, that this lubricating serum accumulates in the visceral cavities; this takes place whenever the function of the system of absorbent vessels is languid, or when its energy is not sufficient for taking up again by suction the quantity of liquid which issues from the arterial extremities. Dropsy then exists, and the liquid which constitutes it, when extracted by the puncture, becomes sufficiently abundant to be subjected to analysis; so that we are then able to ascertain the nature of the internal humour.

21. Rouelle the younger was the first who examined what is called the *hydropic water*. That of the ascites, which he employed, afforded him all the characters of the serum of the blood. I have made the analysis of this liquid, extracted in different species of dropsies, of the breast, of the pericardium, of the ovary, in the ascites, and I have constantly found in it the same characters. This liquid is generally viscous, gluey, yellowish, of a sweetish and somewhat saline taste, charged with flakes more or less abundant and voluminous, of a yellowish-grey colour. It is coagulated by fire, by the acids, by alcohol; it is precipitated by the calcareous and metallic salts; it turns the syrup of violets green: the flakes which swim in it are coagulated albumen; though

though generally fresh and unaltered in the hydropic cavities, it quickly putrefies by the contact of the air. When it is heated, it affords coagulated, porous, light masses, of a sulphur-yellow colour, and tremulous consistence; there remains a slightly yellowish liquid which does not coagulate. When diluted with water and heated, it forms a milky not coagulable liquid; it affords at its surface, by the progress of the action of the fire, a thick yellow pellicle like milk. Boiling water attacks and dissolves the matter that has been coagulated by the fire, so that it then presents the appearance of a gelatinous substance. However, we can obtain no real jelly from this liquor, though strongly evaporated and afterwards cooled; pellicles are separated from its surface from the beginning to the end and during the whole course of this evaporation. The albuminous matter therefore does not exist in it in the real state of gelatin.

22. Sulphur and phosphates are also exhibited by different processes in the hydropic liquor. The first is perceptible by the fetid smell which this liquor exhales when coagulated, by the colour which its vapour imparts to silver, by the sulphuric acid which is formed in it by the oxygenated muriatic acid, and which is discovered by the aid of the muriate of barites. As to the phosphates, lime-water, the solutions of barites and strontian, poured into the hydropic water, produce in it precipitates,

tates, which are easily discovered to be phosphates, on account of their insolubility and the manner in which they comport themselves under the action of fire. The nitric solution of mercury forms in it also a flesh-coloured precipitate. The coat of the hydropic water, evaporated to dryness and burned in a crucible, affords some traces of calcareous phosphates, but less abundant than almost all the coats of other animal matters. It is useless to add, that the coagulum afforded by this water when heated, affords in distillation the same products as those of which I have spoken in the history of the serum.

23. We must not confound with the water of the internal surfaces of the membranes the ropy and mucous liquid which lines the sides of the hollow viscera, of the canals communicating with the external part of the body, opening into the air, and immersing themselves into the interior part of the animal cavities, such as the oesophagus, the trachea, the intestines, the urethra, the vagina, &c. The mucus destined to lubricate these parts and to prevent their dryness and rigidity, is of a different nature from the matter of the transpiration, though, like it, it issues from the surface of the delicate and thin portion of the epidermis which invests those canals, and which is called epithelium. Instead of being evaporable like the transpiration, it contains a kind of gelatinous albumen, little susceptible of desiccation, rather  
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deliquescent, which the air thickens only with difficulty, and which preserves the pliability, softness, and mobility of the sides of the canals where it is deposited. It seems to be of a composition entirely opposite to that of the transpiratory humour, no less susceptible of preserving its viscosity, its soft and as it were unctuous consistence, than the other is of becoming volatilized and dissolved in the air. Accordingly, it performs an entirely different office, since it maintains the softness and heat of the surfaces, whilst the other tends to dry and cool them.



## ARTICLE VI.

*Of the Synovia.*

1. THE Synovia is an unctuous humour, destined to lubricate the articular cavities, and to facilitate the motions of the heads of the bones upon each other. Clopthon-Havers was the first anatomist who described particular glands situated in the articulations as the source of this humour; but some modern physiologists now doubt whether such be the true origin of the Synovia. The following are the arguments which Xavier Bichat principally adduces, in a very good dissertation upon the membrane,



membrane, which includes this liquor, published in the second volume of the Memoirs of the Medical Society of Emulation at Paris. All the articulations do not contain the pretended synovial glands described by Clopthon-Havers. The mucous capsules of the tendons which facilitate the sliding of these parts by the presence of the same humour which their cavity contains, have not generally glands of this nature. Those bodies, which were taken for glands by Clopthon-Havers, are only cellular texture sustaining blood-vessels collected into reddish balls; they are unfolded into floating membranes; they do not tumefy nor harden as the real glands do, and their pretended glandular nature disappears under the scalpel or by other anatomical processes: besides these granulated lumps or cellular balls are found in other places besides the synovial membranes.

2. The same anatomist does not confine himself to combating the opinion of Clopthon-Havers concerning the synovial glands and the source of the Synovia: he has collected a great number of facts and arguments in order to prove that this humour has another origin and to discover whence it proceeds. For this purpose he describes with much greater accuracy and precision than had been done before him, the membrane into which the Synovia exhales, where it remains contained for some time, and is absorbed so as to be perpetually renovated. According to his researches, this  
membrane,

membrane, which he calls *synovial*, and which is inclosed in all the articulations, is a bag, or kind of sac without orifice, folded together, of the nature of the serous membrane, analogous to the pleura, to the pericardium, thin, transparent, distinct from the articular capsule, and to the internal face of which it adheres, detaching itself from it below the heads of the bones, leaving a portion of those bare, passing over the articular cartilages which it covers, adhering strongly to them, folding back upon the inter-articular ligaments and cartilages and the glandiform balls; so that the heads of the bones, the articular capsules, and the interior ligaments of the articulations are on the outside of this synovial membrane. We may extend and inflate it by blowing from the interior of the articulations at the points where the articular capsules are interrupted. It is this synovial membrane, contained, as we see, in the articulations, covering all the interior surfaces, filling their cavity, having a smooth, polished, and shining surface, upon which the sliding of the articulated bones takes place. Citizen Bichat thinks that it is formed by an intertexture of exhalant and absorbent vessels, the first conveying the synovia by exhalation, the second taking it up proportionally.

3. Founded upon this structure, this anatomist who has given an account of it, after having compared this membrane with those which he calls *serous*; that is to say, those

which occupy and invest the large cavities; cover the viscera, and are sacs without orifice, such as the pleura, the pericardium, the peritoneum, the tunica vaginalis or of the testicles, concludes from this analysis that there constantly issues from the interior surface of this internal capsule of the articulations a gluey and viscous liquid, as well as from those of other serous membranes, and that this humour is what is here termed the *Synovia*. In order to confirm the identity of its nature with that of the lubricating humour of all the other cavities of the serous membranes, he follows its analogies under four general relations: 1. its nature is similar; it is, like it, albuminous, since, like the latter, the Synovia, being of a viscous consistence, is coagulable by fire; by the acids, and by alcohol; which Clopthon-Havers had already remarked; 2, it performs the same functions as the humour of the internal cavities, since, like this, it serves to render its surfaces smooth, and to favour the motion of these internal surfaces; 3, the Synovia presents an equally striking analogy with this humour in the diseases to which it is subject; in fact, we observe its thickening give rise to adhesions between the surfaces of the synovial capsules, as between the pleura, the peritonæum, and the viscera which are contained in them; we also find hydropic accumulations of the Synovia, as we do of the humour of the other membranes; 4, finally, the synovial humour is absorbed

absorbed by lymphatic vessels, and renovated by the continually renewed exudation in the interior of the synovial membranes or capsules, like the humour of the other internal cavities.

4. However, Citizen Bichat finds a difference between the apparatus of the synovial capsules, as well as the formation of the Synovia, and the structure of the vessels of the ordinary serous membranes. He observes that the absorbent system of the synovial membranes must differ from that of the other absorbents situated in the other parts of the body, since in the leucophlegmatia the sub-cutaneous absorbents are every where obstructed, whereas this obstruction does not take place in the articulations. This observation, however, is not sufficient for establishing a difference between the two systems, and may be explained by the diversity of the layers of the absorbents; for it is known that the superficial or sub-cutaneous absorbents form a system, if not totally independant of the deep-seated lymphatics, at least sufficiently separated from these not to participate always in the same affections with them. I am much more struck with a difference of infinitely more importance between the Synovia and the humour of the internal cavities; namely, that of the quantity and of the physical properties which very eminently distinguish these two liquids from each other. The latter is never sufficiently abundant to run out at the orifice of the membranes, nor thick and stringy,

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as we find the Synovia: accordingly, when this thickens, it gives rise to anchyloses or solid adhesions of the joints, whereas the humour of the membranous cavities forms only mucous, tenacious and flaxey ligaments.

5. I have already observed that the Synovia is an unctuous liquid: its viscosity is such, that it was formerly compared to an oil, and almost to those greasy matters which are employed for facilitating the motions of wheel-work. This single character, which all anatomists have ascribed to the Synovia, would be sufficient to distinguish it from the humour of the interior cavities, though the expression which has been employed for rendering it is altogether improper. It is in sufficient quantity to be collected with ease at the orifice of the synovial capsules which contain it in the articulations of large animals; it is either transparent or slightly opaque, a little greenish, of a consistence analogous to that of white of egg, of a sweetish and somewhat saline taste, of a faint animal smell, analogous to that of frog's spawn. Its specific gravity is superior to that of distilled water. Physiologists have hitherto given only a very imperfect and very general notion of this liquor. None of them have made a real chymical analysis of it. Citizen Margueron, apothecary to the Maison des Invalides in Paris, read to the Academy of Sciences, in June, 1792, a chemical examination of the Synovia, and this is the only inquiry made with any attention that I know. In exhibiting  
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the results of his experiments, I shall subjoin some reflections concerning the necessity of repeating them and reviewing some facts which deserve all the attention of the philosopher.

6. Citizen Margueron easily procured the Synovia of the bullock from a butcher's shop where several were killed every day. This liquor assumes a gelatinous consistence some time after having been extracted from the joints, both in the cold and in a mild heat, as well in close as in open vessels : it does not long retain this consistence ; it even soon loses its first natural viscosity, and deposits a stringy matter ; it presents some differences in its analysis, according to these different states ; when it is filtrated as soon as it has been extracted from the joints, it nevertheless preserves all its properties. A thin layer of synovia exposed to a dry air in a flat vessel, dries into a scaly net-work, in which two saline matters are observed ; the one in cubes, which is muriate of soda ; the other efflorescence and easily distinguishable as carbonate of soda ; the fresh synovia also turns the syrup of violets green. In a moist air this liquor becomes altered and putrefied ; whilst it loses its viscosity, it becomes turbid, exhales a smell of putrid fish, assumes a red or brown colour, becomes covered with a pellicle, and leaves a soft and fetid residuum, from which lime and the alkalis disengage a large quantity of ammonia. Distilled in the retort, the Synovia afforded Citizen Margueron a very alterable water charged with ammonia ;

ammonia; at last, an empyreumatic oil, carbonate of ammonia, and a coal which contained muriate of soda, and phosphate of lime.

7. The Synovia easily mixes with cold water, in which it first occupies the bottom, but dissolves in it by agitation. The author observes that it gives to water a very remarkable viscous fluidity, as it is very sensible even when we take six parts of water to one of this humour. The mixture froths much by agitation: frequently in ebullition, it preserves its viscosity, becomes opaque, milky, and exhibits some pellicles at the sides of the vessel. The author was so struck with the consistence communicated to water by the synovia, that he asserted no animal liquor presented any thing similar; he thought he had found its cause by the action of the acetous acid. The addition of this acid to the mixture of synovia and water caused it to lose its viscosity, rendered it clear and transparent, made it deposit a mass of white fibres easy to be separated from the liquor, by tubes of glass, which carried them away in a single piece. The liquor thus clarified being put to evaporate, afforded him albuminous pellicles and afterwards crystals of muriate of soda, and of acetite of soda in striated prisms. It was undoubtedly from this experiment that Citizen Margueron supposed albumen to exist in the synovia in two states, more dense than in the other animal liquids, and consequently capable of imparting a greater viscosity

to water. I shall soon show that there is reason to believe that this property may depend upon another cause which could not even have been suspected in 1792, or at least that it deserves to be studied under new relations, and with a new interest, as it may greatly elucidate both the functions of the synovia and the nature of its morbid affections.

8 Citizen Margueron treated the synovia with different acids. The concentrated sulphuric acid, he says, produced a flaky precipitate, easily soluble in the liquor, and which did not destroy its viscosity: the same circumstance is observed, with the sulphureous, nitric, muriatic and acetic acids. Diluted with from 12 to 15 times their weight of water, these acids impair the transparency of the synovia without destroying its viscous consistence; nevertheless, when weakened to such a degree as to leave their acidity scarcely perceptible, they cause the viscosity of this liquor to disappear, render it clear and transparent, and separate from it aropy matter which may easily be obtained insulated. The acetous acid especially presented this character, and he employed it for determining in this manner the proportion of the constituent principles of the synovia. 288 parts of this liquor extracted from the bullock gave him also 24 parts of stringy substance, afterwards 13 parts of albumen in pellicles obtained by evaporation, then 5 parts of muriate of soda



and 3 of acetite of soda ; whence he concluded that it contained 233 parts of water.

9. But what most deserves to engage our attention in this chemical inquiry is undoubtedly the nature of the stringy matter separated from synovia by the addition of the weak acids, upon which Citizen Margueron has made some particular experiments. He has justly considered it as a particular circumstance which does not present itself in any other animal liquor, and which consequently deserved to be studied with some attention. Presuming, from the properties which this substance presented to him, that it could not be real albumen, though he afterwards designated in it the result of his analysis as *albumen in a particular state*, he wished to ascertain whether it might not be compared with the glutinous matter of wheat. He examined it under this new point of view, and he assures us that he did not remark any sensible difference of colour, taste, or odour between these two fluids ; their elasticity and their adhesion to the fingers were the same ; boiling water gave the same consistence to both ; the concentrated acids and alkalis dissolved both equally. However he has observed differences between them ; the ropy matter of the synovia dissolves by agitation in cold water ; this solution froths by agitation ; the acids and alcohol precipitate it in flakes ; caloric produces in it a very white and very rarefied scum. These differences appeared to him sufficiently considerable to induce him to

conclude from his examination that the stringy matter of the synovia was albumen in a particular state. We here find a too manifest contradiction between the different assertions of the author : as he had said some lines higher up that if it had been albumen, *the same means employed in order to obtain it from any other animal matter* would have presented it *in a very different state* ; not to perceive the uncertainty and embarrassment in which he found himself involved by the properties of this singular substance. Hence, I suspect that this matter may really be very different from albumen, and that it deserves to be examined anew with the greatest attention.

10. The synovia affords very perceptible precipitates with lime water, as well as with the alkaline solutions of barites, of pot-ash, of strontian, and even with ammonia. The oxalic acid likewise produces in it a very sensible precipitation : all these effects manifestly proceed from the phosphate of lime which it contains. Citizen Margueron found very sensible traces of salt in its coal ; but he has neither determined its proportions nor discovered the mode of its solution in this liquor, in which however there is reason to believe that it is capable of performing an important function. The carbonates of pot-ash and of soda unite very well with the synovia, without producing any change in its acidity ; the caustic alkalis in sufficient quantity render it more fluid, and even dissolve

the synovia that has been dried by the contact of the air. This last mentioned character of the solubility of the synovia, when thickened by spontaneous evaporation in alkaline liquors, seems to announce in an incontrovertible manner the albuminous nature of this humour: however, we might draw this immediate conclusion; for, besides the uncertainty in which the author of this analysis has been involved by his experiments upon the fibrous part of the synovia precipitated by the weak acids, it is very evident that matters extraneous to albumen are soluble in the caustic alkalis. Besides, the very facility or the complete state of this solution that has been well remarked by Citizen Margueron, does not belong, at least in this degree of energy, to albumen, and seem to indicate another matter, especially an acid; and we shall see in one of the subsequent articles that there are some reasons to suspect the presence of the uric acid in this particular liquor.

11. Alcohol precipitates the synovia without causing its viscosity to disappear. It separates from it white flakes, insoluble in the liquid, the nature of which Citizen Margueron has not indicated. The albuminous part of the synovia is certainly separated by this re-agent, but must be allowed to believe that some other substance is at the same time precipitated, according to what the author of this inquiry has remarked. On adding acetous acid to the  
mixture

mixture of synovia and alcohol the viscosity of this mixture disappears; there is separated, he says, a matter similar to that which he obtained from this liquor treated by the weak acids, and respecting the albuminous nature of which there is room for some objection, according to what I have already advanced. If this liquor contained uric acid or any of its saline combinations, the one or the other would certainly be separated with a portion of albumen; the first as being little soluble in water or not at all soluble in alcohol, the second as being coagulable by this re-agent. It is therefore well proved by this consideration, as well as by all those which I have detailed in the preceding numbers, that the analysis of the synovia still demands farther researches, and promises useful discoveries to such chemists as may think fit to occupy themselves with it.

12. Citizen Margueron had concluded from his analysis that 288 parts of synovia which he had examined as far as to the proportion of its constituent materials, contained 34 parts of albumen *in a particular state*, 13 parts of ordinary albumen, 5 parts of muriate of soda, 2 parts of carbonate of soda, from 1 to 2 parts of phosphate of lime, and 232 parts, or more than three-fourths of its weight of water. I have explained the reasons which induce me to think that this liquid contains, instead of the first of these materials, some particular animal substance, of a nature not yet suspected, which  
must

must have a more or less considerable relation with the diseases which affect this liquor, especially the Anchylosis, the articular concretions, arthritic tophous humours, &c. Should this latter supposition be confirmed by new experiments, it will explain the differences which are already known between the humour of the internal membranes or of the interior membranous cavities, and that of the synovial capsules; it will prove that notwithstanding the analogy of structure which exists, and which I readily admit, with Citizen Xavier Bichat, between the synovial membranes and the other serous membranes, nature has intended, with the same organic apparatus, to give rise to different products, and that we are not to infer, notwithstanding the anatomical resemblances, that the liquids separated by analogous systems of organs must also resemble each other, till after so accurate and so careful a chemical analysis has been made, as to leave no room for doubt or uncertainty.

## ARTICLE VII

*Of the cellular, membranous, tendinous, aponeurotic, ligamentous, glandular Textures, and of the Gelatin or the Glue which these Textures yield.*

1. I COMPREHEND under a single article six organic-animal matters different from each other in their texture, their form, their appearances and their structure, because they are of the same chemical composition, and afford the same products in their analysis. All these different textures are generally diffused in the bodies of man and of the other animals. There is not one of their different regions which does not present a greater or less quantity of them to the scalpel of the anatomist; so that they may be ranked in the class of parts that contribute the most universally to the organization. Each of them has both particular anatomical characters and particular uses that distinguish it. The knowledge that has hitherto been acquired concerning their intimate nature and composition is undoubtedly not so much advanced as that of their anatomical structure; it is however sufficient to approximate them to one another and to oppose them collectively in their chemical properties compared together to the other animal

animal matters. Let us cast a hasty glance upon their structure and characteristic differences, and afterwards see what they present in common with each other, in the phenomena which belong to their decomposition and to the intimate nature of their constituent principles.

2. The cellular texture, which is also called *mucous, cribrous texture*, consists of lamellæ, of thin, transparent, mucous or gelatiniform plates, of a delicacy which exceeds that of the finest gauze, and which may be compared with the light texture which dilated into a spherical form by a current of air blown into a solution of soap. These laminæ are found between the interstices of all the fibres; they are perceived when we separate them; they connect them together, and at the same time separate them from each other; they cannot be well seen except at the moment of this separation; finally, they resemble a gluey form extended upon the parts where they are observed. This texture, called the cellular, *tela cellulosa*, because it was believed to consist of cells opening into each other, forming a continued series throughout the whole body, is in fact found in all its parts. It is situated under the skin in layers, more or less dilated by the fat, on the outside of the muscles and between their fibres, in the intervals which separate them from the contiguous muscles, along the blood-vessels, around and even within all the viscera. They are not small balls or vesicles communicating freely with each other, formed

formed of soft and transparent membranes, as Borden thought, but reticulations of knotted and lymphatic vessels, supported upon membranous laminae, and containing a liquid moving in these ducts.

3. I here denominate membranous texture in general those white, thin, transparent or opaque parts, extended into layers or kinds of tables, frequently folded together, rolled into cylindrical forms, applied in large laminae, inclosing or covering the viscera, forming sometimes wholly or in part entire organs, existing throughout the whole body, and destined either to contain or to separate and insulate the different parts of the body, having only a white or dull grey aspect, without brilliancy, without silvery surface, and never forming solid cords. Such are especially the dura mater, the pia mater and the arachnoid tunic in the cranium, the pleura and pericardium in the thorax, the peritonæum in the abdomen, the sides of the vessels, especially of the absorbents; the periosteum about the bones, the medullary membrane in their interior, the articular and mucous capsules, the vaginal and albuminous tunics and a multitude of other analogous parts. We might even class under the same head the epidermis and the skin, if these organs did not present certain properties which render it necessary for us to consider them in particular.

Citizen Xavier Bichat has published, in the second volume of the Medical Society of Emulation,



Emulation, of Paris, a very good dissertation upon the membranes and their general relations of organization. After having remarked that the anatomists have not sufficiently generalized the structure of these important parts, nor distinguished their varied texture, he divides all the membranes of the human body into three classes: the *mucous*, the *serous*, and the *fibrous* membranes.

The first line the interior of the hollow organs which open upon the external surface of the body; folded or doubled into their internal surface, they are lubricated with a mucous juice; they are continuous with the skin: covered with an epidermis which detaches itself in shreds in some diseases, their principal texture is formed of a spongy tunic which resolves itself into cellular texture by dissection, maceration, &c.; they are endowed with sensibility, and maintain the relations of the interior part of the body with extraneous substances, as the skin does of the exterior; they evacuate by their surface a mucous liquid, constitute a grand emunctory, have diseases peculiar to themselves, such as catarrh and polypus, exhale the animal mucus by friction, irritation, and envelop the bodies which remain in them: such are the interior of the intestines, of the vagina, &c.

The *serous* membranes occupy the large cavities, invest them, cover the viscera placed on the outside of them or in their folds, are sacs without

without orifices, smooth at their internal surface and unequal at their external; they are lubricated in their cavity by a serum that is discharged by exhalation, and sucked up again by the absorbents; whereas the thick mucous of the first is always like an excretion, after it has been separated by cryptous or mucous glands. They have their particular diseases, especially dropfy, adhesions, peculiar inflammations. They are laminae or large sacs which insulate the viscera, which may be considered as grand reservoirs in which the lymph is elaborated, which favour the motion of the viscera. In this order are to be ranked the pleura, the pericardium, the peritonæum, &c.

The *fibrous* membranes, which are less numerous than the two preceding, are hard, of a fibrous and white texture, perforated in order to suffer the vessels to pass through, &c. without folds, thicker than the serous, and less thick than the mucous membranes, without any liquid that moistens them, adhering in all their points, endowed with a particular sensibility and tension, elastic, frequently entering into the organs in which they form a fibrous skeleton, and the texture of which they support. It is in this manner that the periosteum invests the bones, the tunica albuginea, the testicles, &c.

4. The tendinous texture is easy to be distinguished; brilliant and silvery, smooth and polished, consistent and tenacious, strongly resisting pressure and extension, supporting a very heavy

heavy weight before it breaks, formed into a dense and solid cord, rounded or little angular, difficult to be cut, terminating the fleshy fibres, and serving to fix their attachments to the bones, &c. The tendon is the cord, immoveable of itself, which, when drawn by the contracted muscles, causes the bones to move one upon the other. It is in some respect merely a passive agent. It is very difficult to cut it across or perpendicularly with the direction of its fibres; it is easily separated into fascia in the direction of their length. It almost always supposes the existence of the muscles, of which it is a kind of appendage.

5. The aponeuretic texture is a variety of form in the tendon: instead of being a hard and solid cord, the aponeurosis is a kind of membrane which covers the fleshy fibres; which frequently envelops the exterior of the muscles, to the fibres of which it serves as a point of attachment, as a covering which limits their dilatation, as a link which retains their fascia and their fibres adherent to each other. It is distinguished by its fibrous, smooth, polished, silvery, brilliant surface, which sometimes imitates the lustre of silver. It is an intertexture of flat, hard, close fibres, which have several different directions, besides that of the fleshy fibres which they follow in one of their directions.

6. The ligament, as a particular texture, being situated almost always between the bones which  
it

it ties together more or less strongly, from which function it has derived its name, is found in the vicinity of the articulations, and exists in them all without distinction, consequently throughout the whole continuity of the body. It is a compound of grey, solid fibres, very consistent, very tenacious, very resisting, capable of being pretty considerably elongated and drawn without breaking, easily accommodating themselves to all the motions which the articulations admit, permitting a certain separation between the bones which form them, opposing their reciprocal displacement or luxations; arising between the laminæ of the osseous texture itself by filaments which are implanted there, connecting in the same manner some cartilages to the bones, or to each other.

7. Finally, I designate, by the name of glandular texture, the fibrous parenchyma interposed between the bundles of lymphatic vessels, the intertexture of which constitutes the structure of the conglobate glands. This has hitherto been said to be cellular texture, but we need only dissect these glands with some attention, and cut them in different directions, in order to be convinced that this notion is inaccurate. It must be remarked that I do not confound with the texture of the conglobate or lymphatic glands, which are found throughout the body, the parenchyma of some large conglomerate glands or glandular viscera, such as the liver, the spleen, the kidneys, &c.

Each of these viscera has an intimate nature different the one from the other, as they are of a structure peculiar to themselves.

8. These ten organic textures, without being perfectly of the same nature, present however, in most of the trials and experiments to which they are subjected, results sufficiently similar and related with each other, to authorize us to place them together, and to suppose in them an analogous general composition. All of them are insoluble in cold water; and when we leave them to soak or macerate in it for some time, they become swelled, dilated, undergo a separation between their fibres and their laminæ, become soft, mucous, easy to be torn, incoherent in proportion as they are altered. Most of them, fermenting with greater or less rapidity, when they are moistened or immersed in water at a temperature that exceeds 12 degrees of the thermometer, pass into an acid state more or less pungent and sensible to the smell; so that we are tempted to consider them as a kind of vinegar. All of them, after the first period of their spontaneous decomposition, putrefy rapidly, and produce ammonia, which however is disengaged from them in less abundance, and with a less fetid odour than is the case in other animal substances.

9. The same membranous and white animal matters, when exposed to a constant mild fire, or to the contact of air at a degree of temperature exceeding 18 or 20 degrees become brittle  
and

and transparent by drying: they are then unalterable. When they have thus become brittle, and have lost all their tenacity, however, no other intimate change has taken place in them, except the volatilization of the water which their fibres contained, either ready formed, or composed at the very moment of the drying action of the caloric. A stronger heat briskly applied to these dried organs causes them to shrink, to move, to contract in all directions, as we see in a violin-string thrown upon burning coals; afterwards they melt, swell, inflame with difficulty, diffuse an odour of little fetidity, and leave a pretty light coal easy to be incinerated. When we heat them in the retort, we obtain from them the ordinary products of animal matters, but less oil, less carbonate of ammonia, less fetid gas; in general, they appear the least animalized of the animal compounds.

10. The most marked character, or the most characteristic property which these white textures present, is that of softening quickly and dissolving entirely in boiling water, and of forming, when this solution is sufficiently charged, a liquid, viscous and gluey fluid whilst it is hot, which concretes into a transparent and tremulous jelly by cooling. It is in this manner, and with three or four of these textures at a time, that the Flemish or English strong glues, as they are called, are prepared in various manufactories: the Flemish, after having caused these bodies to disappear entirely, or almost

most entirely, by keeping them for a sufficient length of time in boiling water, strain it off clear, and evaporate it to such a degree, that, by cooling, it acquires a perfectly solid consistence. The alimentary jellies, which are also prepared in the kitchens, the tenderest and most savory parts of these white textures being chosen for the purpose, are of the same nature, and differ from the glues only in the choice of the substance of which they are formed, and by the liquor being less thickened and concentrated.

11. We here recognize the same substance as that which has been found in the serum of the blood, coagulated by fire, and which distinguishes itself in it from the albuminous part with which it is mixed, by a semi-transparency, a soft and tremulous consistence, and solubility in water: this is the gelatin. The properties presented, when extracted by water, and in the state of jelly, by this substance, which forms, as we have just seen, the base of the white fibrous or membranous textures, or organs, distinguish it in an eminent manner from albumen, from fibrin, and from every animal matter; its taste is weak and faint; it feels mucous and gluey between the fingers, the temperature of which softens it; it melts in the fire, and even becomes liquid at 56 degrees of temperature; it no longer preserves its original viscidness, does not adhere to the vessels, but runs like water; when it has been left to cool,

cool, it concretes into jelly, as before its fusion, which has not altered it.

12. The gelatin extracted from the white organs, or textures, heated gently and slowly in the liquid form which the first impression of the fire has given it, thickens, becomes coloured, viscid, of the consistence of honey, and at last assumes a concrete, solid, and transparent form, similar to horn. It is then glue, which is hard, elastic, of an orange-yellow, or red colour, brittle, soluble in boiling water, and which, in general, acquires the more solidity, colour, and glutinous tenacity by its solution, as it has been extracted from older or more robust animals. When we subject it to decomposition by the fire in a retort, we obtain from it an ammoniacal water, a fetid oil of little thickness, zoonate of ammonia and ammoniacal carbonate; it affords little gaseous product. The coal which it leaves is light, voluminous, and porous; easy to be burned, affording neither soluble phosphoric salt nor metals, but only phosphate of lime and muriates of soda and pot-ash. The gelatin becomes sensibly acid, before it passes into putrefaction, and affords ammonia.

13. Cold water dissolves it, by being continually agitated with it for some time; hot water immediately melts it, when its temperature exceeds 25 degrees; and this is the reason why jellies cannot be made to assume the proper consistence in the summer without the ut-



most difficulty. When the gelatin has been dissolved in a large quantity of water, it can no longer become fixed into a jelly by cooling, and it is necessary that this too-dilute solution should be evaporated, in order to restore to it this property; it is always made to lose this property of assuming the gelatinous form by refrigeration, in proportion as we multiply the action of the caloric, or expose it too many times to the fire. The acids, even the weakest, dissolve the gelatinous matter very easily and speedily. The alkalis, likewise, possess this property, but in a less marked degree than the acids. The nitric acid disengages but very little azotic gas from the gelatin, and changes only a very small portion into fat, but the greater part into oxalic acid; the solutions of barites, of lime, and of strontian, poured into a solution of gelatin, produce in it a precipitate of phosphate of lime.

14. Several of the properties that have hitherto been described in the gelatin, and especially its form, its transparency in the state of jelly, its acescence; the small quantity of ammonia, of oil, and of fetid gases, which it affords by the action of fire; the small quantity of azotic gas, and oily substance which is extracted from it by the nitric acid, which converts a great part of it into oxalic acid; its rare and swelled coal, are in favour of the opinion of those who considered this matter as having much analogy with the vegetable mucilages, and who believed

lieved it to proceed from the mucous vegetable substance, that had passed almost unchanged into the body of the animal. This, however, is a hypothesis which will appear little probable to those who consider that the nature of every aliment is changed, from its reception into the stomach till its lamellous or fibrous application to the different organic textures which it is destined to nourish; and besides, notwithstanding this analogy between the gelatin and vegetable mucilage, properly so called, there exists a real difference which shows itself in the putrefaction, of which the first is susceptible, but not the other.

15. A still greater difference is constituted by the manner in which tannin acts upon gelatin, whereas it produces no effect upon the vegetable gummy mucilage: when we pour into a solution of animal jelly or glue, water charged with tannin, it produces a precipitate of a fawn-yellow colour, thick, in very fine flakes, which suddenly approach each other, and soon form a ropy, glutinous, elastic mass, extensible by agitation, kneading in the moist hands, like the gluten of the flower of wheat. This compound of tanned gelatin is dried by the contact of the air, becomes hard, brittle, of a smooth texture, brilliant, vitreous, and resinous in its fracture; it is insoluble in water, unalterable in the air; it resists many agents and re-agents; it is incorruptible, analogous to skins that have been too much tanned, and

when it is rubbed it exhales a strong tanny odour; it may be considered as a paste, susceptible of being employed for different uses, and of which the industrious arts might avail themselves with great advantage, if they should occupy themselves with it.

16. Finally, the animal gelatinous matter comports itself also in a very particular manner with alcohol, which does not dissolve it when it is in the form of jelly extracted by water, but even separates it from this liquid when its solution is concentrated, which condenses its fibres or laminæ, when they belong even to the organs, the texture of which they in a great measure constitute: so that these organs, immersed in alcohol, are preserved and condensed in it, without losing any thing of their form and structure, except a small portion of their diameter. This is exemplified in the membranous organs dressed, dissected, and prepared anatomically, and afterwards suspended by threads in bottles filled with alcohol: however, this method of preserving them in the anatomical collections has only a certain period of duration, and at last suffers an intimate change to take place in their texture, which separates from it laminæ, foliations and fibres, the precipitation of which we observe at the bottom of the vessels in which they are contained.

17. Though I consider the six white organic textures as belonging to a single matter, to a single gelatinous chemical compound, the distinguishing

tinguishing character of which is to be insoluble in cold, but soluble in boiling water, so as to give rise to what is called an animal jelly; this notion is, however, not to be understood in too rigorous a sense; neither ought we to consider these six textures as intirely and perfectly homogeneous. The mere difference of their respective form, aspect, colour, structure, density, and tenacity, would sufficiently contradict this pretended identity. Though the chemical analyses, which have not yet been sufficiently multiplied, have not yet led to a sufficiently accurate determination of the circumstances in which the mode of their diversity, so apparent to the anatomist and physiologist, consists; however little advanced this analysis may as yet be, we may nevertheless find in their comparison and in their result, especially when we call to our assistance those presented by the arts that are exercised upon these substances, a series of facts sufficiently interesting to establish some useful distinctions between these different textures, and to satisfy the anatomist, who cannot, from his dissections, be persuaded of this pretended identity of organs, which to him are really very different. It therefore remains for me to remark the varied modifications of chemical nature between the six kinds of textures, which I have hitherto presented only as being of a similar gelatinous nature.

18. The very light and froth-like lamellæ of the cellular, or mucous texture, present the gelatinous matter in the purest, the most insulated and the most marked state; of this we may convince ourselves, by the mere consideration of what happens to them by their action in boiling water. These lamellæ dissolve and melt so completely, that they disappear in the water of these decoctions, and all the fibres which they connected together are afterwards found separated, incoherent, naked, destitute of the integument which enveloped them on all sides, and the water thus performs a kind of dissection, which is frequently of use to the anatomist in his dissections. It is the solution of this texture accompanying the flesh which gives to certain broths the property of concreting into a jelly.

19. The textures of thin white transparent membranes, such as the pia mater, the arachnoid tunic, the epiploon; those of stronger membranes, as the substance of the peritonæum, of the pleura, of the pericardium, part of the tunics of the stomach and of the intestines, the periosteum, differ a little from the cellular lamellæ properly so called; though anatomists have believed them to be formed of these lamellæ united and condensed, from the circumstance that water does not attack them, except with much greater difficulty and with the aid of a longer space of time. In order to  
dissolve

dissolve them it is necessary to let them macerate for several days in warm water, to separate the lamellæ and fill their interstices with the aqueous liquid, and afterwards to boil them for a long time in a large quantity of water, and keep them immersed in it, agitating them incessantly. We should affirm that the gelatin is not so pure in it, that it is enveloped, as it were, in an insoluble and tenacious substance which prevents its fusion. The manufacturers of glue are well aware of this difficulty; the animal matter is sufficiently dense, sufficiently compact in these organs, to dry in the air when these membranous parts are thin and extended, as is exemplified in the art of making cat-gut strings. We may also combine slowly, particle by particle, the substance of this texture with tannin; and at some future time advantage will be derived from this kind of tanning of membranes or intestines, by keeping them for some hours immersed in a solution of tan, in order to communicate to them a greater solidity and an useful inalterability, at the same time preserving their tenacity and elasticity. For the rest, Chemical analysis has not exactly determined in what this difference between the membranous texture properly so called and the cellular texture consists; but it is now in progress towards determining it.

20. The tendons and the aponeuroses, which are flat tendons, though consisting of solid cords or very tenacious layers, approach more  
to

to the cellular texture properly so called. It is remarked in the boiled meat which is served up at our tables : all its tendinous and aponeurotic parts are melted or softened, when they are well boiled, into a sort of yellowish, transparent, gelatinous glue, which some persons prefer, and which in fact has a sufficiently agreeable taste. In the preparation of glues, all the tendons are melted and disappear entirely in the water ; they even form the major part of the gluey substance, and give to water that consistence and viscosity, from whence jelly is produced by cooling. When the tendons, being drawn out and extended in order to make them present a larger surface to the air, are dried, they become transparent and solid, and at the same time acquire a yellow or reddish colour, as we see in dry anatomical preparations.

21. The ligamentous texture, though it also contains gelatin which is extracted from it by boiling water, is nevertheless of all the white organs that which partakes the least of the gelatinous nature. The familiar and domestic fact of the meat boiled in our aliments proves this in a direct manner. At the side of a tendon that has been softened and melted into jelly we frequently see upon our tables a cord, generally flat and thick, of a white opaque matter, hardly at all softened, and of such tenacity and hardness that it is impossible for the teeth to attack it, and which cannot be eaten, on account of its excessive resistance to mastica-

maſtication. This very remarkable want of ſolution, at the ſide of membranes of the ſame fleſh, ſoftened and diſſolved in the ſame water and in the ſame of time, announces not only that the ligamentous texture is much more denſe than that of the other white parts, but that it is probably of another nature; reſpecting which chemiſtry has not yet decided. The ſame is the caſe with the membranous coats of the arteries and veins. Beſides the fleſhy fibrils and the cellular layers which form a part of them, there is in their texture a matter analogous to the ligament, which reſiſts the action of boiling water, and is not converted into gelatin like the preceding textures: it is poſſible that this matter might be formed by the fibrin; but we have no fact that proves it with the accuracy requiſite to authorize us to admit the reſult. This texture of the blood-veſſels is extremely different from that of the lymphatic veſſels: the latter though ſufficiently hard and reſiſting in proportion to its extreme tenuity, nevertheless melts pretty quickly in water and forms jelly, as we ſee in the laminæ of the cellular texture, which modern anatomists have diſcovered to be a tiſſue of abſorbent veſſels.

22. I muſt obſerve the ſame of the texture of the conglobate glands, designated by anatomists as bundles of lymphatic veſſels folded together and united with each other by cellular texture. Were this its real nature and ſtructure, this texture would ſoften and melt intirely in water, to which



which it would impart the gelatinous character. However, instead of dissolving in this manner, though they do yield a little jelly, the conglobate glands harden and resist the action of a large quantity of boiling water. This resistance is still more considerable in the texture of such of these glands as have acquired a more or less considerable enlargement, and a greater or less degree of induration, in the chronic affections that have been designated in so improper, or at least in so vague a manner, by the name of obstructions, as we find them in persons afflicted with scrophula, &c.

23. Finally, the texture of the skin, which has always been compared with that of the preceding white, soft, and membranous organs in general, and which in fact presents a very striking analogy with them, has however very considerable differences from them; besides which, the important uses for which it is destined, and the remarkable utility which it has in many of the arts, have induced me to treat of it in particular.

24. Neither shall I speak here of the nervous texture diffused throughout the whole body, as it will more naturally require to be considered under the article concerning the brain.

## ARTICLE VIII.

*Of the Muscular or Fleishy Texture.*

1. THE white, soft, and membranous textures in general, which have been described in the preceding article, form collectively a class of organic matters well characterized and well distinguished from all others; and by ranking it as the first in the order of the general solid textures, or of those belonging to the whole body of animals, or which are found distinctly in all its regions, I observe that we must refer to three other classes all the different matters which embrace the same universality of organism, or contribute to the general construction of all the organs of animals. I place in the second class the muscular or fleshy texture, in the third the horny texture, and in the fourth the intirely solid or osseous texture. The present article is destined for the history of the muscular texture.

2. The muscles, which in their totality and generality comprehend the fleshy or muscular texture, are one of the most important and most useful classes of organs in the animated machine; in them and by them it is that the power of life executes the different motions which maintain it, or which incessantly supply  
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its wants; it is by means of their contraction, of the irritability or the force which produces this contraction, this shortening of the fibres which brings together those substances to which they are attached, that the animal moves, transports itself in space, slowly traverses the surface of the earth, bounds to some distance from this surface, rises, or supports itself in the atmosphere, advances, descends, rises or dives in the water; it is these which execute the intermitting and concealed motions which constitute life, standing, walking, vaulting, flying, swimming, the flexion, the extension of the different parts, or the sensible action of partial or total locomotion, subjected to the will or those passions which so eminently distinguish the class of organized and animated beings from that of the plants.

3. When we consider the muscles in their relations with the other parts of the body of animals, we find in them a new motive of interest for studying their properties, because the muscular system forms one of the most considerable masses of the animal organization. Their totality occupies a very large space in the economy of the animal: covered by the skin, contained in aponeuroses, covering on all sides the bones which they envelop and adorn, it is they that give form and torsity to the members. Their projecting and protuberant parts, together with the depressions of their intervals, display all the forms which  
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the statuary and the painter imitate in their most finished works, by the aid of which they present to our eyes the majesty of a god in the Apollo, the expression of anguish in the Laocoon, invincible strength in Hercules, vigour and dexterity in the wrestler, the bloom of youth in the Antinous, or grace and beauty in the Venus.

4. The muscles are supplied with liquids by a great number of blood-vessels, which wind along their surface, and enter amongst their fibres, by lymphatic vessels which are also situated round their fibres and in the interstices which separate them. We find in them nerves which are distributed, and lose themselves in their fasciæ; cellular texture with which they are abundantly provided, aponeurotic membranes which surround them, tendons which terminate them. Though all these parts are only accessory to their texture properly so called, anatomists consider them as belonging to their organization, and in fact they all contribute to their functions: the cellular texture connects their fibres; the blood-vessels nourish and warm them; the absorbent vessels take up the superfluity of their nourishment, and carry off the parts that are worn by the vital actions; the nerves convey into them the immediate cause of their motions, and the order of the will which commands them, of whatever nature this cause may be; the tendons determine their action upon such or such parts; the aponeu-  
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roses afford a point of support to their fasciæ. There is also fat both on the outside and in the inside of their fibres, which are thereby enabled to slide easily upon one another. The totality and the integrity of these different textures, which penetrate them and constitute them living organs, are necessary to the exercise of their functions; and when the one or the other is deficient or suffers, the muscle loses a part or the whole of its activity: on this account some of the anatomists have supposed the muscles to be formed of cellular texture; others have believed them to be constituted of nervous filaments; and some have considered them only as vascular extremities.

5. The analysis of the muscles provided with all the organic parts which constitute their totality is not, therefore, nor can it be, exact, since it confounds a great number of different textures together. If it were true that such was the contexture and the composition of these organs of motion, we could not flatter ourselves with the hope of being able to ascertain their nature, except by the analysis of each of these parts; and when once each of them was well known, nothing more would remain to be done in order to determine that of the muscle. Formerly the analysis was confined to the distilling of the flesh, and designating the quantity of phlegm, of spirit, of volatile salt, of oil and of coal which it afforded: we must add to this ancient notion, that amongst the products

products of the flesh we obtain a remarkable quantity of zoonic acid combined with ammonia, and that the muscle appears to be amongst the animal substances that which furnishes the most of this acid. Geoffroy, the physician, has described the effect of water, and quantity of soluble matter which it takes up by ebullition from a great number of different sorts of flesh, with respect to the nutritious-matter contained in each of them. This inquiry is of no value, except with respect to the alimentary property. Thouvenel was the first who endeavoured to ascertain the different principles, or rather the constituent materials of the muscles; for this purpose he employed several processes which had not been practised before him, and which enabled him to give a rather more accurate notion of the nature of these organs. I have since occupied myself with the base itself, or with the parenchyma peculiar to the muscles, and consequently with their real texture, independent of all the substances that are only accessory to it.

6. While it is impossible to insulate the muscular texture properly so called from the vascular and nervous textures, from the sanguineous, lymphatic, adipose liquids that are intimately mixed with it, we must content ourselves, in treating of the chemical properties of the muscle, with investigating and separating those which belong to each of those animal matters in particular, and attributing to the muscular

muscular flesh those only which do not characterize these matters. This method of exclusion may lead, as we shall soon see, to a somewhat accurate knowledge of the nature of the fleshy fibre. Modern chemists have treated the muscle like a vegetable matter mixed with several different substances, which they have endeavoured to separate from one another, first by mechanical means, afterwards by chemical processes. As the organ is filled with sanguineous and lymphatic vessels, which contain liquids, Thouvenel employed the action of the press for separating them. The fluids which he obtained were treated successively by caloric, which coagulated their albuminous matter, and caused their salts to crystallize by evaporation; and by alcohol, which dissolved some of their salts, and a particular extractive substance, which this chemist believed to be peculiar to the muscles. He made different successive applications of water to the residuum of the first evaporated liquid, in order to separate from it the gelatin and the salts; but these means did not conduct him to his end so exactly as he had hoped; and in fact they present great difficulty in the execution.

7. I have succeeded better in this analysis by first washing the muscle in cold water, which carries away the blood and the lymph, and which when the flesh has been cut small and worked with water poured in a stream upon its surface, soon leaves the white muscular texture

ture insulated, mixed indeed with vascular tubes, nervous filaments, cellular laminae of which we may afterwards effect a kind of separation by the aid of the process which I shall indicate. The water which has washed and discoloured the flesh perfectly resembles blood diluted with water; if we heat it, it coagulates and separates at its surface in brownish-red flakes, as happens with the colouring part of the blood; at the same time there are deposited fibrous filaments, in small quantity indeed, but which may be distinguished to be fibrin. The liquor (which is little coloured after this action of the fire, and is slightly turbid and milky) when gently evaporated, affords albuminous pellicles, which are separated, becomes coloured, acquires a taste somewhat acrid when it is concentrated, concretes into a light jelly by cooling, and affords, when evaporated to dryness, a residuum of a brown-red colour, from which we obtain, by a well-conducted application of alcohol and water employed successively, a sort of sapid extract of which I shall soon speak, with a small quantity of gelatin, and phosphates of soda and of ammonia.

8. We see that cold water applied to flesh extracts from it, together with the sanguineous and lymphatic liquor, a small portion of extractive and sapid matter, which belongs peculiarly to this organ. When the flesh is thus deprived of what it contained of matter soluble in cold water; if we boil it in water, it still suffers an



albuminous substance to escape, which is collected into greyish flakes at the top of the liquor, and also a substance which floats like drops of oil at its surface. The fleshy fibres separate from each other, and the dissolved lymphatic and cellular texture give the water the property of concret-  
ing into a jelly by cooling. A well-managed evaporation of this decoction of flesh previously discoloured, still exhibits a portion of saponaceous extractive matter, which acquires colour by concentration, with some traces of phosphoric salts. The product of this decoction is a kind of bad soup, which has not all the properties of that which is prepared with the intire and unwashed flesh, of which we shall soon speak: however, it differs from it only by its containing fewer principles.

9. After these two successive actions, first of cold water, and afterwards of boiling water upon the muscles, if each of them has been carried as far as it can go, there remains only a fibrous parenchyma, of a dirty grey colour, and insipid, which so far from dissolving in hot water becomes hardened by its action; which dries and becomes brittle in dry and hot air, and presents all the characters of the fibrin of the blood, especially its solubility in the weak acids, the property of yielding by the fire much ammoniacal carbonate and a fetid oil; that of affording azotic gas in abundance by the action of the nitric acid, which converts it into yellow fat floating at the surface, and  
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Oxalic acid dissolved in the liquor. I have concluded, from my researches concerning this fleshy parenchyma, that it is formed immediately by the blood poured so abundantly by nature into the texture of the muscle; that the nutrition of this organ consists in the separation of the fibrin; that it is undoubtedly on this account, that not only the blood is very abundant in it, but that it is also retarded in its course before it penetrates into the interior of the fibres, by curvatures and tortuosities; since, according to the celebrated Haller, a great number of arteries pursue a tortuous and retrograde course, before they plunge themselves deep into the muscles. It is under this relation that I have represented the blood as liquid flesh, according to the expression of the Father of medicine.

10. When flesh is boiled in water without previously washing it, a large portion of the ferous and coloured albuminous matter separates in brown flakes, coagulated by the action of the heat, and forms the scum which is taken off; another portion of the same matter remains adhering to the flesh, and gives it that brownish fawn colour which, as is generally observed, becomes darker by the contact of the air: the water gradually dissolves the gelatinous matter belonging to the cellular and lymphatic texture of the muscles, melts and separates the fat which swims at the surface, dissolves both the phosphoric salts, and a par-

ticular extractive matter, which gives it the clear yellow colour, the aromatic odour, and the rather pungent and agreeable taste, which every one knows in flesh broth. This alimentary liquor, therefore, when well prepared, is a solution of gelatinous matter, of an extractive animal substance, of phosphate and of muriate of soda and of ammonia; it moreover contains a small quantity of fatty oil, dissolved by the aid of the gelatin and of the extract, a small quantity of albuminous matter, and even a small portion of phosphate of lime.

11. Flesh broth presents to chemical examination a series of phenomena, which prove the presence of these different matters. This liquid is susceptible of turning sour in hot seasons, on account of the gelatinous matter which it contains; acetous acid is then formed in it. Lime-water, or ammonia, produces in it a slight precipitate of phosphate of lime in a white powder; the oxalic acid shows the lime it contains by the white deposition which it occasions in it; nitrate of silver indicates the presence of muriatic acid; the nitrate of mercury occasions a white precipitate, which acquires a rose-colour by drying in the air, and is a mixture of mercurial phosphate and muriate, coloured by an animal matter. When we slowly evaporate the flesh broth, it assumes an orange and brown-red colour, a stronger consistence, and a somewhat acrid taste; and, in this state, it is called (in French) *consommé*.  
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Most of the soups reduced to this state congeal, by cooling, into a tremulous jelly; those which are made with the flesh of young animals present it the soonest, on account of the large quantity of gelatin which they contain. By continuing the action of a gentle fire, we obtain, after a more and more decided inspissation, a matter which becomes solid by cooling, of a brown-red colour, having a strong and acrid taste, which keeps for a long time without alteration, which melts intirely in hot water, and forms a soup which considerably resembles that which is originally made with the flesh; this is what is called *extract, or tablets of soup*, (portable soup) because this substance is poured into the moulds of tin, in which it assumes the form of tablets. If we distil this extract of broth, besides the products common to other animal matters, we obtain a considerable quantity of zoonate of ammonia.

12. When the extract, or portable soup, is prepared for the uses of life, and for voyages, the process is not confined to making a soup of simple flesh. The flesh of the bullock, the calf, and of poultry, are mixed together; to these are added savoury vegetables, carrots, onions, cellery, some spices, especially cloves, with muriate of soda in sufficient quantity, so that it actually becomes a mixture of several different extracts, seasoned with saline and aromatic matters, mixed with the portion  
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of saccharine matter contained in the vegetables. Accordingly they have a strong taste, and a lively smell, different from that of mere boiled meat. The portable soup keeps for a pretty considerable time. However, it becomes altered after some years; it becomes covered with a white saline efflorescence; it attracts humidity, and softens and becomes mouldy at its surface. The true and pure extract of meat would be neither savoury nor agreeable, in comparison with that of which I have been speaking: it is, however, this extract whose properties we must examine, in order to make ourselves acquainted with one of the principal materials of muscular flesh.

13. The extractive matter taken up from the muscle by boiling water, is obtained by lixiviating the product of the soup, evaporated to the consistence of thick honey, with alcohol: this re-agent attacks neither the gelatin nor the most of the salts contained in this product. By evaporating this alcohol, which is highly coloured, we obtain a brown-red matter, of a pungent and even acrid taste, and of a particular aromatic odour; when heated a little more strongly than is requisite for drying it, it boils and swells, and assumes the smell and saccharine taste of caramel: it appears that it is this which forms upon roast meat that brown, shining, and highly sapid incrustation, which is called the *brown (rissolé)*. This extract remains soft in the air, and gives the portable  
soup

soup its deliquescent property. Heated strongly upon a burning coal, it becomes liquefied, swells, exhales a white smoke, and an acid smell. Distilled in the retort, it affords water containing zoonic acid and zoonate of ammonia. Its coal contains muriates of soda and of pot-ash; dissolved in water, it gives it a deep red colour: this solution becomes sour in the air, and partly passes into the state of vinegar, depositing some coal. It still remains to be determined, whether this kind of extract be contained ready formed in the muscular flesh, or whether it be not produced by the decomposition of the fibrous texture, effected by the action of the caloric.

14. The different facts relative to the analysis of the muscular texture, which have just been enunciated, serve to account for what happens to the muscle, when it is exposed to the action of different agents in its intire state, and without the different materials having been separated from it. We may thus understand, that in the baking or roasting of meat, the albumen is condensed, the gelatin melted, the extract dried, the fibrin penetrated with juice is rendered tender, the salts are concentrated, and the flesh, whilst it assumes a brown colour, acquires a taste and properties very different from those which it has in its crude state. If, instead of heating the flesh strongly enough, and for a sufficient length of time to bake or roast it, we heat it but very slightly, and so as only to evaporate

evaporate the water contained in it, it dries, becomes coloured, brittle, and may afterwards be preserved for a long time. The acids soften the muscle, and dissolve it by acting upon its fibrous part. The concentrated caustic alkalis alter, melt, and dissolve it, forming ammonia and oil, with which they constitute a kind of soap. Ammonia produces no perceptible change in it.

15. Many saline substances preserve the muscular flesh, and prevent its putrefaction. Thus muscular anatomical preparations are immersed in a solution of alum, in which, however, the flesh is at last altered and converted into a kind of fat. Fixed oil, the butters, and the fats, with which it may be surrounded, or covered, contribute to preserve it; the volatile oils, the resins, the odorous woods, the bitter and aromatic leaves and barks, act also as anti-putrescent, and prevent the septic decomposition of this texture. Tannin dissolved in water also penetrates its fibres, precipitates in them the gelatinous matter, and surrounds them with a layer of tanned matter, which equally opposes their putrefaction. Alcohol contracts and condenses its texture, so that it cannot afterwards undergo that kind of spontaneous alteration which tends to destroy its composition.

16. The muscle left exposed to the air, putrefies very quickly, when the temperature of the atmosphere exceeds 15 degrees. Its component parts at first exhale a faint or musty smell; it  
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acquires a livid colour, which grows darker in proportion as the putrid decomposition advances; its texture softens and melts at the surface into a kind of liquid putrilage; the smell becomes fetid, strong, and ammoniacal; sometimes there is disengaged at its surface a phosphoric light, which shines both in water and in the air, and subsists for several successive days. When the whole of the flesh has been equally softened, dissolved, and turned green by putrefaction, it at last leaves, continually exhaling a fetid odour, a brown or blackish residuum, which, for a long time, is soft and moist, but dries after several months into a kind of animal mould, in which we find some traces of fat, of carbon, and of alkaline phosphate and muriate. When the muscular flesh experiences the putrefactive motion, after having been immersed in water, its decomposition gives rise to another product. There is formed a fatty, white, fusible matter, considerably resembling what is called *spermaceti*, and which I have already designated by the name of *adipocire*. This phenomena takes place so constantly, as I first observed fourteen years ago, in all the muscles of the carcases of animals exposed upon the borders of rivers, brooks, and lakes, that I have proposed its re-production in order to procure, from animal remains that are generally thrown away in the country, and even in large towns, a kind of fat which may be of use in several of the arts. It was undoubtedly from  
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this proposal that Mr. Gibbes has described this new art in the volume of the Royal Society of London, for the year 1797.

17. It still belongs to the province of chemistry to determine the changes which the muscles experience in different kinds of diseases which attack their texture, and at the same time alter their intimate nature or composition. This art will show what happens to them in the diminution of their alterability, in the softness which they sometimes acquire, and which renders them very easy to be torn, in their acquiring the bright red or light brown colour, which characterizes them in the course of other affections, and especially in the white colour, and fatty unctuous aspect which they contract in the course of long continued paralytic immobility and insensibility.

18. The difference of the muscles in the different orders of animals is also one of the most important objects of chemical research for the animal philosophy, but unfortunately one of the least advanced; for we can scarcely reckon amongst these researches the first experiments made more than sixty years ago by Geoffroy upon the nutritive quality of different kinds of flesh compared with each other. The object of chemical analysis ought to be to resolve the following questions, the solution of which can be expected from this alone. In what does the muscular flesh of the mammalia of the chase, characterized under the name of

*black meat* or *venison* by its brown or dark red colour, differ from that of the ordinary mammalia? Are the muscles of the carnivorous animals different from those of the frugivorous? How does the composition of the flesh of young animals differ from that of the same animals more advanced in age? Is the white flesh of birds of a different nature from that of the mammalia and from that of the birds with black and odorous flesh, as well as from the oily and hard flesh of water-fowl? What is the comparative nature of the flesh of fishes, both in the cartilaginous and in the prickly species, of that of the sea and of fresh-water fishes, of that of the oviparous quadrupeds, of serpents, of insects, and of the testacea? All these questions, and many others to which these will naturally lead, are adapted to throw the greatest light upon the phenomena of life, of irritability, of the tonic force, &c.

#### ARTICLE IX.

*Of the Dermoid Texture, or of the Skin, and of the Epidermoid Texture, or the Epidermis.*

1. THE body of the greater number of animals is enveloped, and all its organs are covered by several layers of different membranes, which

which are called in general teguments. In man, in whom this cutaneous covering is the most perfect and the best organized, as it is not only destined to contain all the other parts, but also to form the seat of the sense of touch, which is more or less deficient in most of the animals; the teguments are composed of three membranes or three successive layers; the innermost, that which is applied immediately upon the fatty cellular texture, is the thickest, the strongest, the most resisting: it is the skin properly so called, or the derma. Above and on the outside of this first tegument is a soft, cellular, areolar, mucous layer, formed of a thin net-work, the meshes of which are filled with a kind of gelatinous texture, in the midst of which are placed as upon cushions, the papillary extremities of the nerves, the seat of the touch: this second layer is the reticular texture of Malpighi. Finally, on the outside of and above this second texture, is applied a fine, transparent membrane, dry externally, which covers the nerves, and is known by the name of epidermis. In the animals this last covering varies greatly; there is besides, under the skin, a flat muscle, generally diffused over the whole body, which is called the *fleshy panícula*.

2. These three successive teguments differ in the different parts of the body; they are fine and delicate in some parts, thicker, and more solid in others. The nerves of touch in man  
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are more multiplied and of a more elegant, more regular, and more distinct structure at the extremities of the fingers. The derma is in general and in all animals extensible, perforated with holes which permit the nerves, the hairs, and the extremities of the arteries to pass through; it varies greatly with respect to its thickness, its elasticity, its tenacity, in the animals of different orders and genera. The reticular and mucous texture is more or less soft, dense, and thick, according to the parts to which it belongs; it has neither the same organization, nor the same extent, nor the same functions in the animals whose skin is covered with hairs, feathers, or scales. It is charged with a black matter in negroes; and when it has been destroyed by a wound or ulcer, this portion of the skin remains white in the cicatrix;

The epidermis is an almost inorganic membrane; it is composed of laminæ or plates disposed in such a manner that their edges cover each other like the scales of fishes. It is transparent, and very thin: it is re-produced very easily and very quickly; its place is supplied by real hard and horny scales in fishes, in serpents, and in the oviparous quadrupeds.

In general there exists no organic texture more varied and more different in itself than the whole of the integuments in the different orders or genera of animals. It would require a very extensive anatomical dissertation to point out only their principal differences, and these details

details would here be out of place. It may be sufficient to remark that it is in the diversity of the skin, and especially in that of the extremities and appendages which cover, defend, or arm it, that the principal apparent difference of these beings consists, and that this is constantly the indication or the seat of a more or less considerable difference in the primitive or interior organs of animals.

3. Instead of considering all the varied modifications of properties and of structure of the different orders of animals,—modifications concerning which chemistry will at some future period have as many details and precise notions to give as the anatomical descriptions furnish, and which will diffuse over the arts and the employment of the tegumentous texture in general a light which would in vain be expected from any other science; I shall occupy myself only with its general composition, which presents more or less analogy in all animals. The skin of man, and of some of the mammalia, will more particularly serve me as example; and in treating of the character of some other skins, I shall only endeavour to seize their most remarkable relations. I shall examine more particularly the three different textures of the human skin, because it is the most complicated in its organization; and I shall make it as it were the type to which I shall refer the properties of the other species of cutaneous textures of animals.

4. The

4. The derma, or the skin properly so called, when well separated from the fat, the cellular laminæ, and the vessels which adhere to it, as well as from the muscular fibres with which it is provided in animals, is a thick, hard membrane, capable of being extended, elastic, difficult to be cut, presenting fibres arranged or disposed like the hairs of felt, leaving some areolar interstices between them of a white colour. When it is briskly heated, it contracts and is agitated; upon burning coals it melts, swells, exhales a fetid odour, and is reduced into a coal considerably difficult to be burned. It affords by the retort nearly the same principles as the fibrous matter, a thick oil, and much carbonate of ammonia. The products are in general very fetid; weak acids soften it, swell it, give it transparency and dissolve it; the nitric acid disengages from it much azotic gas and Prussic acid, and changes it into fat and oxalic acid: the concentrated caustic alkalies dissolve it, and convert it into ammonia and oil. It is converted by its spontaneous decomposition in water, and in moist and fat earth, into adipocirous matter and ammonia, as may be observed in burying places. The skins of the carcases that have been buried for several years, are found very distinct and separate from the subjacent parts, presenting a grey layer, considerably greasy, brittle, and exhibiting all the characters of an ammoniacal soap.

5. The

5. The action of water upon the derma is the process whereby its nature and composition are ascertained in the most accurate manner. The derma, immersed and kept in cold water, dilates, becomes slightly softened, swells, loses some of its tenacity, and at length becoming at the same time thicker, suffers the hairs which cover it to be pulled out with ease, after which it becomes semi-transparent, and seems to affect the gelatinous nature by this maceration. When the skin is left for a long time in this fluid, it becomes altered, putrefies, emits a strong fœtor, becomes like a soft jelly, and assumes an ammoniacal smell. If, instead of letting it putrefy in this manner, we boil in it a sufficient quantity of water after it has been swelled, we see it melt, dissolve entirely, and form a viscid, gluey, thick, ropy, and even glairy liquor, which acquires a homogenous consistence and liquidity when it is boiled for a sufficient length of time. In this manner is formed a real animal mucilage, a jelly which becomes fixed or congealed by refrigeration, and which affords glue by evaporation and concentration. In many of the arts this property is well known and employed with much success. Different glues are prepared with glove-skin, eel-skin, shreds of the skins of quadrupeds, of different fishes, &c. It is easy by this single process to find a remarkable difference between the different kinds of skins. That of  
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fishes melts quickly; that of man and of the mammalia, of the bullock and of the horse, do not dissolve, except with the addition of more water, heat, and time; but all of them, when subjected to a sufficient maceration, at last melt in the water, and pass to the state of jelly or glue.

6. When we observe with great attention what happens in this transition of the dermoid texture into the state of gelatin by ebullition in water, we remark that the skin of the bullock or of the horse, which is very analogous in this respect to the human skin, presents, previous to its melting, fibrous or filamentous flakes which swim in the liquor, and do not dissolve without much difficulty, whilst another portion has been dissolved by the first impression of the boiling water. Hence it has been concluded that the dermoid texture is composed of two principal matters, the gelatin and the fibrin. Citizen Seguin, who has much occupied himself with the analysis of this texture, with a view towards determining the theory and perfecting the art of tanning skins, has formed more mature notions relative to its composition than chemistry before possessed respecting this object. According to him, the cutaneous fibre, being very analogous to the sanguineous or muscular fibrin, is only a kind of oxygenated gelatin, incapable of being combined in its fibrous state with water and the tannin principle: it is necessary to unburn it as it were, or to deprive it of a



portion of its oxygen, in order to render it susceptible of uniting with the tannin. It appears that a similar difoxygenation takes place in the long and successive action of cold and of boiling water upon the derma, since from having been fibrous and insoluble at first it at last becomes entirely soluble and gelatinous. The effect of the great and speedy solubility of the skins of fishes and of oviparous quadrupeds, and the facility with which they form jelly, as well as the large quantity which they afford, is in favour of this idea of the oxygenated nature of the derma, since it appears to approach the nearer to the gelatinous state as it belongs to animals that respire less, that require less atmospheric oxygen, and whose blood is the least heated.

7. The observations and experiments which Citizen Seguin has made upon tanning, having led him to this theory of the nature of the texture of the skin, it is necessary to give the result of his experiments in this place. The precipitate of glue or of pure gelatin by tannin is brittle, and if the derma were purely gelatinous, tanned skins would be equally brittle. The fibrous texture of the derma does not combine with the tannin; but when we cause it to return to the gelatinous state by taking oxygen from it we render it susceptible of combining it with tannin. This is what is done in the preliminary clearing, softening, and swelling of the skins before they are subjected to the tanning operation

tion. The fibrous part and texture of the derma being of an irritable nature, the action of the weak acids or alkalies causes the small hollow filaments of these fibres to contract and thicken, till, by this action itself, this property is exhausted by the effect of shortening, which diminishes the length, and increases the thickness of the derma. Its gelatinous part is dilated, divided, easy to be dissolved and actually dissolved in the water with which it is soaked; at the same time that its fibrin, dilated and shortened, is unburned by losing a portion of its oxygen. In proportion as it is disoxygenated, it combines with the tannin which is deposited in it: it must not be too much unburned, nor return to the state of pure gelatin; which would render it over-tanned and too brittle: it is on this account that in the swelling, the portion of gelatin which it contains is taken from it. The gallic acid which exists in the tanning water, already exhausted of tannin by the skins, and which is discovered in it by its precipitating the sulphate of iron in the black state, particularly effects this decomposition of the fibrous part of the skin, as we see it effect the disoxygenation of silver, of gold, and of several other metals when we pour it into their solutions: it is on this account that the exhausted tanning water is so useful for the swelling and unhairing of the skins. Finally, the fibrous derma, thus unburned, shortened, irritated and afterwards combined in a semi-gelatinous state with tannin,

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having lost its irritable property and primitive nature, can no longer be shortened nor change its dimensions. However this tanned compound which in good leather is not real tanned gelatin, may still be elongated and flattened, and preserve a sort of ductility under the hammer of the shoemaker who beats and works it ; but it keeps, like the metals, the dimensions which it has acquired by pressure.

8. We may therefore draw the following inferences from these ingenious observations relative to the nature of the derma: that it is in general formed of two textures or two distinct matters; the one of which is gelatinous, immediately soluble in water and immediately precipitable by tannin: this is extracted from the ordinary skins of quadrupeds before they are tanned. The other matter, the true solid, extensible, elastic, irritable texture of the skin of man, of the mammalia, and of the birds, is the fibrin or oxygenated gelatin; it contains the former in its meshes; it contracts in one direction and swells in its length by the action of the saline stimuli; it is unburned by the acids, by long exposure in water, and by ebullition; it returns to the gelatinous or semi-gelatinous state according to the proportion of oxygen that is taken from it. It is undoubtedly in the proportion of these two matters that the difference of the two kinds of skins consists, which is variable according to the nature of the animals, their manner of living, their very high or very low degree of oxygenation, &c.

9. The

9. The reticular texture of Malpighi, or the mucous net-work situated immediately upon the surface of the derma, and which contains the nervous papillæ destined for the perception of the touch, appears to be composed of two different substances ; a soft gelatinous covering extended over the whole surface of the skin and very light, and very fine granulated tubercles, which are nothing else than nervous expansions. Chemical analysis has not been able to operate upon this texture, as it is so fine and delicate, that it cannot be separately detached, and several anatomists have denied its existence, not having been able to discern it, even with the aid of strong magnifying glasses and microscopes. It is supposed that the black colour of the negroes has its seat in this texture, and that it depends upon a colouring matter diffused in it, because this black substance may be removed by means of solvents without touching the derma and leaving it white, and because the layers of the epidermis when skilfully separated are transparent and colourless. Nothing has yet been done with respect to the colouring matter of the skin of negroes, neither do we know what is its nature ; we know however that it is capable of being discoloured and passing into a yellow tinge by the contact of the oxygenated muriatic acid. A negro who had placed his foot in a ley of oxygenated muriatic acid, and held it for some time in that liquid, presented the part almost discoloured and inclining to whiteness ; but a black colour

as beautiful and as pure as that which it had before was entirely formed at the end of some days.

10. The scaly, dry and transparent texture of the epidermis in man proves by its mere aspect, that it differs remarkably from that of the cutis: it is far from being so distinct in the animals. When the human skin is boiled in water, according to the observation of Citizen Chaptal, it first grows tough, and separates into two distinct parts: the leather, or the cutis, which contracts, thickens and acquires the consistence of a softened cartilage; and the epidermis, which does not dissolve, whereas a continued ebullition changes the cutis into a gelatinous mucilage. Alcohol does not attack the epidermis, even when kept for a long time in digestion upon this membrane. The caustic alkaline leys dissolve it with ease. The same solution is obtained with lime water; but this solution does not take place unless during of a much longer space of time than that which the pure alkali requires: this we perceive even in rubbing a caustic alkaline ley between the fingers; for it assumes an oily consistence and feel, in proportion as the ley acts upon the epidermis which it dissolves. Citizen Chaptal finds in those properties an analogy between the external epidermis of the human body and the matter which covers silk. He observes that when a skin, provided with its epidermis, is immersed into a solution of tannin, the

the latter only penetrates it on the flesh side, and that the epidermis, which does not combine with this substance, prevents its passing from the side of the hair or grain side. In the unflensing, the epidermis is removed from the skin, which then admits the tannin at both its surfaces; and the lime, which is generally employed in this operation, acts as a solvent of this exterior membrane. Lime-water, on account of the small quantity of the earth which it contains, acts but very little, and requires to be renewed in order to separate this external membrane.

#### ARTICLE X.

##### *Of the Corneous Texture, of the Hairs, and of the Nails or Hoofs.*

1. SCARCELY any part of the surface of the human body is entirely destitute of hairs; indeed they are well marked and in considerable quantities only in certain regions, especially the axillæ, the pubes, the linea alba, the front of the breast, the region of the shoulder blades, the thighs and legs, the back of the hands, part of the face, of the chin, and the upper part of the neck. There are some individuals in whom almost the whole surface of the body is hairy, but these are in general

general rare. The palm of the hands, the soles of the feet, the red part of the lips, the surface of the prepuce and of the glands, and in general all the parts that are covered with the *epithelium*, are the only part which are constantly destitute of hair. They are disposed in a regular manner in some parts, curved into arches in the eye-brows, bent and projecting in the eye-lashes, rigid and like small pincers in the nostrils, when they are called *vibices*; erect and in tufts in the concha of the ears, turned in different directions upon the chin, curled and short upon the pubis, the axillæ, &c.

2. The skin of the cranium is provided with long hairs very close to each other, destined to descend over the forehead; the ears, the back of the head and shoulders, when they are suffered to grow, constituting, like the beard, the natural ornament of man, and a defence against the rain, the heat of the sun, insects, falls and blows, cold, &c. The hairs of the head have not the same structure as those of the other parts of the body, though they are of the same nature. Much more tufted and straight, they grow to a much more considerable length, and their growth has no real limits. Men differ very much from one another with respect to the nature of their hairs; and their races are characterized by hairs long and straight, short, curly or crisped, soft or rigid, long or short.

3. The colour of the hairs also constitutes one of the most remarkable differences; it  
varies

varies in different countries, latitudes, climates, temperatures, ages, and sexes. The human foetus has them frequently white; they remain so in cold countries: however, in the most rigorous climates and towards the poles they are brown. In the fiftieth degree of latitude, according to Haller, red hair was formerly the most frequent. The hotter the climates are, the more the hair approaches to the black. An exception to this rule are the Albinos, so called on account of their pale-blue skin and their milk-white hair. It is generally said, that cold and phlegmatic temperaments that abound in white juices are characterized by very fair hair; that the choleric temperament produces red hair, and the sanguine black. Whatever be the climate, the hairs constantly turn white in old men, and become transparent by the dryness of their centre. It is also commonly said that grief turns the hair white, though most physiologists deny the certainty of this fact. Some diseases produce this effect. In several animals, especially hares and rabbits, the hair becomes white in the winter, particularly towards their points. The diameter of the hairs of the head has been estimated at between  $\frac{1}{300}$  and  $\frac{1}{700}$  of an inch. Withof counted 572 black hairs in the space of an inch, 608 brown, and 790 fair; so that the latter are reckoned to be the thinnest.

4. The hairs have a very remarkable structure, which has been very well described by several



several anatomists, especially Malpighi, Ledermuller, Withof, Chirac, and Haller. Under the cutis, and in the midst of the fat which distends the cellular texture, are implanted in this cutaneous fat which appears to be their true seat, oval, flat, reddish bulbs, formed of a hard, elastic, exterior tunic, and supplied by sanguineous vessels. The interior of this external integument, which is hard and easy to be cut into small laminæ, and from which a more or less viscous sanguineous liquid flows when it is open or punctured, contains a smaller bulb, cylindrical, oblong, hard and white. The base of the hair is inclosed in this interior bulb; the hair in it is finer, and softer than in its exterior part, crooked and conical. It issues from the tube covered with two integuments furnished by the membrane of both bulbs. When it has arrived at the pore of the skin through which it passes, it relinquishes its exterior covering, and retains only the interior. In passing immediately under the epidermis, it raises and pushes before it this membrane, which surrounds it, and thus furnishes it with a second exterior covering. This second tunic adheres strongly to the proper tunic which the hair receives from the interior bulb: it is transparent, hard, and corneous. When we cut this epidermoid tunic, we find the interior texture of the hair composed of from five to ten filaments connected together by a mucous and gluey texture; this interior and central texture

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of the hair is thick as in the bulb itself : it shrinks and disappears by drying.

5. To this structure described by the anatomists, and especially by the illustrious Haller, I shall add that the exterior covering appears frequently to form scales detached from the surface of the hair, towards the upper part of each, like small branches diverging from it; and that it is on this account that when we rub a hair between two fingers, it always raises itself, like the beard of corn, in the direction from its base towards its point: so that when we pass this delicate organ between the fingers with a rotatory motion, we may easily distinguish its base from its point by the circumstance that it always moves in the direction of the latter; that is to say, it ascends if the point be placed downwards, and descends if it be placed uppermost. It is by this structure, which answers instead of ramifications, and acts as it had very short branches, that Citizen Monge has explained the effect of felting which hairs experience by the mere friction or percussion which is applied to them: these small filaments become engaged in their reciprocal notches, and are thus solidly hooked together by pressing them close against each other. It is also evident, according to the structure that has been indicated, that the hairs, viewed by the microscope, must appear like kinds of sticks transparent and solid, like scales or horn; that when we cut them, and view their horizontal section,

section, or the perpendicular with their axis, they must exhibit a kind of marrow at their centre; that this central medullary texture, proceeding from the interior bulb, must, by drying, leave the membranes alone, transparent and dry, and give whiteness to the hairs; that when they begin to dry they must split at their extremities, and that it is on this account that we frequently find them bifurcated. It is also evident, that on account of their double covering, and of the medullary and filamentous centre which they contain, the hairs must possess a certain strength, and support some weight without breaking.

6. We may also consider the hairs as hollow tubes, or ducts, communicating immediately with the cellular texture, capable of pouring into the atmosphere a vaporous liquid, or one susceptible of dissolving in it, and constituting a particular emunctory. They are capable of impeding the electric fluid, and of insulating those bodies which they cover, as silk does. They possess, like many animal textures, the hygrometric property in so marked a degree, that they are employed for constructing hygrometers in preference to all others. It is on this account that the hair so readily loses its curl by the contact of water, of dew, or of fogs. The hairs dry and fall off in diseases; their bulbs are frequently destroyed by depraved states, or ulcerations of the cellular texture. They swell and become painful, though insensible in their proper

per texture, by the effect of the *plica polonica*. Their diameters, being augmented in this affection, permits the blood to flow out by their extremities; and it is upon this principle that we are to account for the drops of blood, or the hæmorrhages, which follow the cutting off the hair in this terrible malady. Finally, the hairs receive such an influence from external bodies, that the persons who work copper have them coloured green by the oxide of this metal, even in their interior part, and not merely in their external layers.

7. After having described the structure and the physical properties of the hairs, we must occupy ourselves with the examination of their chemical properties. Formerly the analysis of these bodies was attempted by the action of fire: Neuman having treated a pound of hair in the retort, obtained from it five ounces and six drachms of urinous spirit, two ounces and one drachm of concrete volatile salt, three ounces and six drachms of oil, four ounces and three drachms of caput mortuum, containing twenty one grains of salt. But notwithstanding this kind of repartition of the products of six ounces of distilled hairs by Neuman, it is evident that his analysis was far from being exact, as he intirely neglected the elastic fluids which are disengaged in abundance from distilled hairs, and of which he had taken no account; and as he found again the total weight,

weight, it cannot be doubted that he was obliged to suppose the quantity of some of the liquid products, which he alone collected, to be more considerable. We shall see, by the exposition of a more recent analysis, that there are still other errors in that of Neuman.

8. It is to Citizen Berthollet that we owe this second analysis, which is much more exact than that of Neuman, though the French chemist published it in 1776, in his *Observations upon the Air*, at a period when the analytical processes were infinitely less advanced and perfected than they are at present. Two ounces of hair afforded Citizen Berthollet one drachm and eighteen grains, or, nearly a thirteenth of their weight of ammoniacal carbonate; two drachms and a half, or more than a sixth of their weight of water, having a very strong smell of burned hair, and ammoniacal from the commencement of the distillation; four drachms, or a fourth of their weight of an oil, very different from that which is obtained from the other animal substances: and lastly, there remained four drachms and a half, or more than a fourth of their weight, of a coal, the particles of which were very sensibly attracted by the magnet, and which he was not able to calcine. This chemist, is estimating at a drachm and a quarter the portion of water, of oil, and of ammoniacal carbonate lost, states at two drachms and eighteen grains the elastic fluids disengaged,

gaged, the nature of which he has not indicated, and which are manifestly carbonated hydrogen gas, mixed with carbonic acid.

9. In the account of this analysis, he insists particularly upon the oil afforded by the hairs, on account of its large quantity, as well as of its very remarkable properties, and its difference from all the other oils obtained from different animal substances. This oil was yellow at first, and became black only at the end of the distillation. It did not alter the colour of the ammoniacal carbonate; it was very soluble in alcohol; it burned with the scintillation and vivacity which every one remarks in the intire hairs when burning; it remained in a concrete form till the eighteenth degree of Reaumur's thermometer: its weight was not much different from that of the water charged with ammoniacal carbonate obtained in this analysis; so that when fluid it swam at the top, and when concrete it sunk to the bottom of this liquid. He concludes from these observations, that the hairs are principally composed of oil; but this conclusion, which might be admitted still in 1776, but which can no longer be considered as exact, must now be considered only as a simple proof of the great disposition which the hairs have to assume the oily character, as is proved in fact by their violent inflammation, their fusibility, their fatty nature, and the impracticability, not only of dissolving them in water, but even of wetting them. It is

is also to be observed that this opinion of the learned French Chemists accords with that of Haller, who, in his great physiological work, remarks a singular analogy between the hairs and the fat, the constant situation of the former in the latter, and the frequent circumstances of morbid fatty concretions, or steatomes filled with hairs.

10. The quantity of carbonate of ammonia afforded by the hairs appeared so considerable to Haller, and struck his attention so forcibly, that he was astonished that J. Godard, who described the secret of the preparation of the English drops bought by Charles II. King of England, employed silk and not hair, which, he says, would have more easily afforded him an abundant quantity of this salt. This same abundance led Citizen Berthollet to doubt in 1760, whether the volatile alkali did not exist ready formed in the hairs; and it is certain that no animal substance affords it so abundantly or so quickly. It is likewise very remarkable that its coal is so difficult to be burned, and that it contains a very sensible quantity of iron attractable by the magnet. We should be tempted to believe, according to this fact, that the hairs contain in their interior the colouring part of the blood, and that their coal, like that of this colouring part, contains phosphate of iron. This coal is hard and brilliant, adheres strongly to the glass, and resembles carbonate of iron: there is reason to believe that this coal is  
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also charged with phosphate of lime ; for Citizen Vauquelin and myself have found this salt in the hairs of the horse and in the claws of several animals ; and these parts have the most perfect analogy in their nature and composition with the human hairs. There is also a little carbonate of lime in the ashes of hair ; black hair even appears to afford more of it than fair.

11. The hairs are those parts of the human body that endure the longest ; they do not contain the same principle of decomposition and of change of nature which exists in most of the other animal substances ; they are more durable even than the bones ; and in ancient sepulchres in which the skeletons were reduced to powder, or intirely destroyed by the action of water and air, the hairs still subsist, after having resisted the efforts of ages, and attest that human bodies had been deposited in them. It is very easy to conceive that this preservation depends intirely upon the corneous insoluble nature of the hair, and that not being alterable either by air or water, which gradually melt and attenuate all the other animal substances, they retain their properties and their composition even in the midst of the destruction which seizes upon all the organic parts. Garman in his Treatise *De miraculis mortuorum*, adduces a great number of facts and observations which prove this indestructibility and inalterability of the hairs.



12. Though so little alterable, the hairs are however not exempt from the impression of several re-agents which more or less change their nature. Strong ebullition in water, frequently employed in the arts in which these bodies are worked, causes them to undergo a softening and partial fusion, the first signs of which are perceived in the hygrometrical action which cold water exercises upon them. Some persons even pretend that when they are boiled for a very long time, they become intirely melted in the water and form a jelly ; others assure us that it is only a portion of the covering of the hair, and not its proper interior substance, which dissolves in the water, and affords the gelatin which is obtained from it. No chemist has hitherto examined this action with sufficient attention. The decoction of hair is always coloured.

13. The acids also soften the hairs and discolour them : the muriatic acid whitens them at first, but they become yellow by drying ; the nitric acid gives them a golden colour. The alkalis dissolve them very well and reduce them to the state of a kind of reddish liquid soap, disengaging from them ammonia and approaching them to the oily state. The metallic oxides in general burn, and consequently blacken the hairs : they are frequently employed for colouring them upon the head. Thus when they are rubbed or impregnated with fat charged with red oxide of lead and lime, they become black

at the end of some days. There are also employed for this purpose acetite of lead, sometimes even nitrate of lead, or the nitrates of mercury and of silver. After the use of these metallic solutions, the hairs are rubbed with oil, and become still blacker by its contact. In all these phenomena hair greatly resembles silk, more especially the horns of the mammalia, the shell of the tortoise, &c. Those properties which have been described relative to the epidermis also exhibit a great analogy with the texture of the hairs.

14. The nails, which anatomists justly consider as a prolongation of the epidermis, and like this last, cover a mucofo-nervous and papillary texture, grow, lengthen, and are renewed without limitation, as is exemplified upon the fingers of the Faquirs of Malabar. Duverny has compared them with horn, and Ludwig with hair, and in fact they are of a very similar nature or composition. They soften by long maceration and decoction in water; this decoction is rendered but very little turbid by tannin,—still less than that of the hair; they cannot be completely dissolved. They dissolve in the acids, are melted in the alkalies, are coloured and burned in the metallic solutions, and they adhere to colouring matters and are solidly dyed, as we may see by inspecting the hands of dyers.

15. It may be concluded from all these facts, that the corneous animal texture and especially the matter of the epidermis, of the

hairs and of the nails is an oxygenated gelatinous substance, little or not at all soluble, rendered solid, elastic, unalterable and very durable in its intimate nature, not only by its state of oxygenation, but also by its union with a considerable quantity of phosphate of lime, and even with a small quantity of carbonate of lime ; so that these concrescible and little soluble salts, being deposited with an oxygenated gelatinous matter exist as it were in the state of a tanned substance. Every fact announces that these corneous textures, so abundant upon the surface of the body of man and of animals, are reservoirs into which the excess of the nutritive matter and of phosphate of lime is deposited. The first is deposited in them especially at that period of their life when their growth has ceased ; the second is collected in them, especially in those animals from which the urine does not carry off this matter of the bones, as I shall show in speaking of the urinary liquids and of the osseous texture : accordingly, the mammalia of which I speak, have their skin entirely covered with hair ; whilst man, whose skin is almost bare, evacuates by urine the excess or too great abundance of osseous matter.

## ARTICLE XI.

*Of the Cartilaginous Texture.*

1. THE cartilaginous texture has a consistence and structure which sufficiently distinguish it from all others ; it is an almost solid body, white, of a milky transparency, considerably resembling to the colour of the chalcedony or the opal, susceptible of compression, highly elastic, easy to be cut, smooth and polished in its section, like a resinous matter, granulated or like shagreen in its fracture. It has not the hardness of the corneous texture, but is intermediate between this substance and the ligament. The cartilages are most frequently situated at the articular extremities of the bones which they cover, and into the texture of which they enter, or between bones which they keep asunder and soften their friction, whether they be moveable or fixed. Sometimes they constitute particular kinds of organs, as in the human larynx.

2. The structure of the cartilaginous texture is difficult to be determined and described, and Haller acknowledged that it was much more obscure than that of the bones. It is not distinguished from the latter in the foetus. Its difference from the osseous texture is very slight  
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in those of the larynx and of the ribs; it is seldom or never converted into osseous texture in the two parts of the larynx and the ribs. In some cartilages we see, in the interior, a sort of core, or granulated texture, covered with a whiter and finer matter: it is very difficult to discern laminæ or fibres in this part. The tendons that undergo a strong pressure, become converted into cartilages, like that of the peronæus longus in its passage under the cubiform bone: the thyroid gland, the tunics of the large arteries, the sides of cysts and of aneurisms frequently become cartilaginous. The first rudiments of the bones in the human body are real cartilages; in the adult, and by the progress of ossification, they have only a slight cartilaginous crust at their extremity. The articular and inter-articular cartilages never become ossified, on account of their continual humectation. The intervertebral cartilages formed into ligamentous rings at their extremity, and into a glutinous, thick, white humour, similar to a flakey starch, at their centre, become ossified but very rarely.

3. Some familiar and domestic facts are well adapted for affording a notion of the chemical nature of cartilage. It is known that this animal matter softens in water; that, by its softening, the laminæ, or the fibres which enter into its structure, become perceptible by swelling, splitting, detaching themselves from the osseous surface in their divided part; that they assume  
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the gelatinous nature by long ebullition, and the transparency which characterizes this substance. These phenomena present themselves at the extremities of the bones which accompany the meat which we boil, and many persons prefer these cartilaginous parts when softened and converted into jelly by boiling. Hunter, one of the anatomists who have occupied themselves the most with the nature of cartilage compared with several other animal parts, has collected several experiments by which he has endeavoured to prove the difference of its texture from that of the bones. According to his experiments, the cartilages are not softened in the acids; they dissolve completely in hot water. They are not coloured like the bones, or along with them by madder mixed with the food of animals.

4. To these characteristic properties it is added, that the cartilages do not exfoliate in diseases; that they do not soften like the bones; that they are not re-produced after having been destroyed. These comparative observations we owe to Hunter. Haller concludes, from a comparison of these facts, that cartilage is formed of thickened gluten, into which it may be converted by art; that this gluten receives, as it becomes concrete, a slight portion of calcareous matter, or of phosphate of lime, which renders it solid; that it is on this account that cartilaginous texture is formed in the sides of the arteries, in the membranes of the spleen, in the

the thick part of the pleura, of the pericardium into which a glutinous humour is poured; that their ossification, which takes place in some cases, or with very old subjects, depends upon a too great quantity of calcareous matter, which is precipitated and collected in their ascular texture, as well on account of its known superabundance in old persons, as by the dilatation of the vessels which convey the nutritive juice. This great anatomist concludes from the analogy of the cartilage with the bones, that there must exist in the one as well as in the other, fibres and laminæ, but that they are concealed by the opaque and homogeneous gluten, which covers them on all sides.

§. While borrowing these general considerations from the immortal work of the Helvetian physiologist, I have endeavoured to supply the silence of the chemists respecting the nature of the cartilages: I do not know of any particular analysis having been made of them. If what Haller advances were perfectly exact, it would follow that the cartilages are of a composition similar to that of the corneous texture; but this analogy, at least if taken in all the latitude in which it is here presented, is not probable, because the mere aspect of the cartilaginous texture, its living properties, and its morbid alterations, prove that there exists a very remarkable difference between the two textures. We must indeed admit the presence of the phosphate of  
lime

lime in cartilage, as well as in the corneous texture; but it appears, that besides a remarkable difference in the proportion, the gelatinous matter of the first differs from that of the second by a modification, which chemistry is alone able to determine, and may throw much light upon the very imperfect knowledge we yet possess of the intimate nature of cartilage.

## ARTICLE XII.

### *Of the Osseous Texture.*

1. THE system, or the totality of the bones, which support the whole animal machine, and give its general figure, its size and its firmness, forms the last solid texture which remains to be examined; for the bones are the last parts which we find in the order of dissection; those which constitute the last term of nutrition, and into the nature of which several of the preceding textures pass. There exists in the animal economy a power which tends to produce the osseous matter, and to deposit it in most of the other organs. Accordingly, the natural termination of life in animals seems to depend upon this ossification which predominates over the other functions, and opposes their exercise. The bones constitute one of the parts  
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the most generally diffused throughout the whole continuity of the animal body, for here is no region of which the base is not a solid or osseous organ. They must, therefore, be reckoned amongst textures belonging to the whole animal economy, and performing one of the principal functions of life which support its existence.

2. All the bones being connected together by ligamentous fibres, united and articulated, form a system subdivided and moveable in a great number of points; without being removed or separated in the healthy state; they constitute all together what is called the skeleton. Their solidity, their white colour, their elasticity, and their density, distinguish them sufficiently from all the other organs. In order to characterize them, they are distinguished, amongst the numerous bones which form the skeleton, into the flat, the long, the cylindrical, the cubical, &c. We observe in them polished surfaces, cavities, eminences, or apophyses, depressions, impressions, asperities, grooves, sinuosities, canals, which, whilst they characterize each in particular, remind us, by their mere aspect, of their relations, and contiguities with many other parts, with the uses for which they are destined. Their extremities generally present projecting or excavated surfaces, fittings, heads, cavities, condyles, pullics, either naked or more frequently covered with cartilages destined for uniting them closely with the contiguous

iguous bones, or permitting them to move, to slide upon each other, and to change their respective situation more or less considerably. In young animals, the bones are more numerous, many of them being separated into several others, and present detached or distinct parts, which are called *epiphyses*. These separated parts disappear with advancing age, and the bones even adhere at several points to one another, so that in old age the skeleton tends to form only a single piece. All the bones are covered with a membrane which adheres very strongly to them, in several very distinct laminae, and is called the *periosteum*. Anatomy occupies itself with this external structure, with the description of the bones one after the other, in so accurate and detailed a manner, that great part of the works upon this science is consecrated to it, because it is considered as the base of all the other parts of anatomical knowledge. The instructed eye, on surveying the skeleton, soon applies to it all the other parts, so that it becomes the type upon which memory raises, as nature herself seems to have done, the whole edifice of the animal body.

3. The internal structure of the bones is no less important to be known than their surface and their figure, especially in order to arrive at the determination of their intimate nature or composition. These solid organs appear, when broken, to be formed of laminae applied to

to each other, sometimes very close and compact, as in the centre of the long bones, sometimes separate, and leaving between them porous cavities, presenting small vesicles, like those of a sponge: accordingly, this latter texture is called spongy or cellular. The flat bones are, in general, formed of two tables, having a space between them, and supported by some solid fibres passing out of one table into the other; the intervening space is filled with a reddish soft texture, which is called *diploe*. In the long bones, there is a medullary cavity or canal, full of a kind of fat called *marrow*, which is deposited in a cellular membrane detached from the interior periosteum, and itself supported upon some osseous laminae, or some filaments detached from the internal surface of these bones; blood-vessels which perforate the body of the bone obliquely arrive at this internal periosteum, and pour into it the liquid which nourishes them. The middle part of the long bones is composed of very close laminae, forming a considerable thickness: towards the extremities these laminae diverge from one another, separate, and form by their separation osseous cells, which constitute the whole thickness and the whole strength of the heads of the bones; so that these dilated extreme parts, which are very thin in their external osseous layer, nevertheless resist a great degree of pressure by the considerable number of plates and of solid columns which bear upon the

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the internal surface of the layer. The cellular texture of these dilated extreme parts, or of these heads, of these condyles of the long bones, is filled with a juice analogous to the diploe which is found between the tables of the flat bones.. However close the laminæ of the bones may be in their solid part, they nevertheless easily suffer a part of the medullary oil placed in their interior cavities to insinuate itself between them. The bones have an elastic texture susceptible of a certain degree of extension, of a certain elongation before it breaks.

4. The external and internal structure of the bones has been known much earlier than their intimate nature or composition. Exact and even minute descriptions of their surfaces, their slightest inequalities, of all their parts, were already completed; the great works of Vesalius, of Columbus, of Riolanus, of Clopton-Havers, of Albinus, of Monro, of Bertin, and of many other celebrated anatomists, had brought this descriptive part to its perfection; many curious researches had even been made upon osteogeny or the formation of the bones; and the valuable discoveries of Kerkringius, of Duhamel, of Foucheroux, of Haller, of Troja, &c. had already thrown some light upon this beautiful part of physiology, before chemists had discovered the real nature of these organs. Till 1774, we contented ourselves with distilling the bones, determining their products in an inaccurate

inaccurate manner, loosely ranking their base amongst the earths, though it had been suspected that it had constituted a particular earth. - Papin, Herissant, Laffone, Haller, had carefully distinguished and proved by experiments that the bones were formed of two different substances; the one glutinous, susceptible of dissolving in boiling water, and forming a jelly which was prepared for the uses of several of the arts; and another substance which had been considered as calcareous or absorbent; when one of those capital discoveries, which tend to change the aspect of the science, was made by two Swedish chemists. - Gahn and Scheele proved, by exact experiments, that the pretended osseous earth was an earthy salt composed of phosphoric acid, and lime, which could not consequently be converted into lime by the action of fire, nor saturate the acids after the manner of an ordinary absorbent earth. This discovery was soon confirmed by a great number of chemists, especially in France, where the process of the decomposition of the bones, as well as the art of extracting the phosphorus, was simplified by Rouelle the younger, Macquer, Poulletier de la Salle, Nicolas de Nancy, and Berniard. It will soon be seen that by a late course of inquiries made by Citizen Vauquelin and myself in conjunction, we have added a new degree of precision to the analysis of the calcareous phosphate of the bones.

5. The bones exposed to fire in contact with the air, if we begin by a mild temperature, first dry and become brittle; then a fatty oil escapes from their interior and turns their external layers yellow. To the aqueous vapour which is first exhaled, succeeds, when the action of the fire is augmented, a fetid and greasy smell; the surface of the bone becomes brown, a thick white vapour is disengaged from it; it then takes fire, and continues to burn till the whole of its oil is dissipated. The bones are then black and in the state of coal when they are suffered to cool; but when they are heated to redness, their coally matter burns from the surface to their internal part, and they are at last changed into a white friable substance, insoluble in water: such are the calcined bones which are used in the arts for rubbing and polishing diamonds, and forming cupels. These calcined bones, lixiviated in water and by the acids, afford a little carbonate of soda, carbonate of lime, and a large quantity of calcareous phosphate. The proportion of this saline earthy substance, with respect to the whole bone, is 0,65 as the average term of many varieties with respect to the age, the state of this organ, its solidity, &c. If we heat the calcined bones to an intense redness, they experience, at the same time emitting a yellowish, phosphoric light with which they seem to be penetrated, a semi-fusion which assimilates them to the state of porcelain. They have a fine  
close

close femi-vitreous grain, a great degree of density, a femi-transparency, and that soft aspect which belongs to all the vitrified earths.

6. When we treat the bones in close apparatuses, distil them in a retort, from the mildest temperature which is usually employed in these operations to the most intense heat which these vessels can support, we obtain water which gradually assumes the oily ammoniacal colour and smell, oil partly liquid and light, partly heavy and concrete, of a brown-red colour, very fetid; carbonate of ammonia dissolved in water and in a concrete form, soiled by a portion of oil, a carbonated and sulphurated hydrogen gas, and carbonic acid gas. There remains in the retort a coal which retains the form of the bone that has been put into the vessel. When we carefully examine the water which is obtained in considerable abundance in this distillation, we find in it, besides the ammoniacal carbonate, a small quantity of sebatic and of Prussic acid combined with ammonia: the thick oil, separated from the other products and subjected to rectification, becomes in part liquid, volatile, of an almost aromatic smell, and in every respect similar to what is called *Dippel's animal oil*; it is always a little ammoniacal, and turns the syrup of violets green. The coal calcined in open vessels heated to whiteness, affords the same results as those which have been enunciated in Article 5. Formerly the products of the distillation of the bones were

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employed

employed in medicine, and those obtained from the human cranium, or from the horns of deer, were preferred. It is very evident that these products of the combustion and of the distillation of the waters, with the vapours, the inflammation, and the liquid and gaseous products, are owing to the gelatinous or truly animal portion of these parts; for the earthy salts can neither be their cause or their source.

7. Bones exposed to the air gradually become dry, brittle and arid; they become white when they are long exposed to the dew; and afterwards turn yellow, especially by age and during hot seasons; whilst they thus acquire colour, they become greasy and oily at their surface. After a great length of time having been turned brown by a kind of slow combustion, they decay, separate into small scales, and fall into powder. It is in this manner that they are gradually destroyed in the fields and in burying places; but ages are scarcely sufficient to effect this destruction. I have examined some that had remained nearly three hundred years in a charnel-house, defended indeed against the rain, which were still very hard and elastic, and contained their gelatinous part almost entire. Van Swieten mentions a skeleton kept in his museum, the bones of which were spontaneously destroyed, and fell into powder by the effect of a virus which, according to him, still existed in this subject, and re-acted upon the texture and the composition of its



bones. It is known that these organs receive, and easily promote the germination of small seeds of vegetables which cover their surface with a greenish moss ; that when buried in the ground, they admit carbonate of lime into their pores, which the water deposits between their layers, at the same time depriving them of a part of their gelatin ; that they are sometimes incrusted with it, and improperly take the name of *petrified bones* ; and lastly, that when penetrated by a solution of oxide of copper, they acquire a green colour, and are called *turquoises*.

8. The action of water upon bones is one of the phenomena which has been the longest known, and which has been employed with the greatest success for determining their nature. Cold water acts but very slowly upon these organs ; when they remain in it for some days, it gradually penetrates their pores, divides and separates their laminæ, and softens their gelatinous parenchyma : their medullary juice is easily converted into adipocirous matter. Boiling water attacks their texture, when they have previously been reduced into small fragments, into chips, into powder, or into thin laminæ ; it dissolves their white cartilaginous matter, and quickly changes it into very pure gelatin : these bodies are in preference used for preparing the whitest, the most transparent, and the mildest jelly, which is the most capable of receiving all the most varied perfumes, or seasonings. Thus a light and agreeable

agreeable aliment is extracted from hartshorn. Thus ivory and bones afford a nutriment useful in certain circumstances. The gelatinous substance of the bones is softened in these organs in their entire state, when they are subjected to water raised to a temperature much superior to that of its ordinary ebullition, as takes place by the strong compression in Papin's machine or digester, in which the most solid bones are softened in a few minutes. These bodies, thus deprived by the water of their gelatinous substance, become afterwards, when slowly heated, dry, brittle, and friable; and their laminæ separate easily from one another. I speak here only of the action of water upon the osseous laminæ when pure and separated from all that does not belong to them. The proportion of this gelatin, *extracted* from bones by means of water, appears to be from 0,25 to 0,35. If we heat entire and fresh bones in this liquid, their periosteum, as well as the tendons and ligaments which remain attached to it, are dissolved and increase the proportion of gelatin; their marrow melts and collects at the surface in the form of oil. This is the reason why they contribute to the mild and unctuous alimentary quality of broth. The stomach and the digestive power effect the decomposition of bones still better than hot water, and those animals which take them as food, discharge them in a great measure deprived of their gelatinous matter, as is proved by the

chemical analysis of the excrements of dogs that eat bones, excrements formerly called in the materia medica by the ridiculous name of *album græcum*. -

9. It has long been known that the weakest acids have the power of softening bones, and of dissolving that part of them which was called *earthy*. Herissant, in examining this phenomenon with some attention in a Memoir inserted amongst those of the Academy of Sciences of Paris, for 1758, thought he had found in the nitric acid (with which he softened the bones which he soaked in it, by dissolving their earth, which he believed to be cretaceous, without affecting their membranous cellular part) a means of insulating the two constituent matters of these organs. Haller has verified this softening of the bones even by the acetous acid and lemon juice: he suspected that in the softening of the bones by the effect of diseases, there existed an acid which thus corroded them. All the chemists have afterwards observed that a solution of bones in an acid precipitated by alkali affords a seemingly earthy matter, which does not possess the property of becoming quick-lime by calcination. It is to Scheele that we are indebted for the true knowledge of this phenomenon. After having, like Herissant, dissolved bones in the nitric acid, he filtrated the liquor, and ascertained that, though always acid, even when saturated with all that it could dissolve of bone, it precipitated  
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fulphate of lime by the addition of concentrated sulphuric acid; and that after this precipitation, the solution drawn off clear, and evaporated in a retort, afforded volatilized nitric acid, and left phosphoric acid, which was fused into glass by the action of a sufficient heat. He concluded from this experiment that the nitric acid dissolved the phosphate of lime, the base of the bones; that the solution in this acid was a mixture of calcareous nitrate and of phosphoric acid; that when the first was decomposed by the sulphuric acid, and the precipitated fulphate of lime separated from it, there remained only a mixture of the two acids, the phosphoric and the nitric, and that this latter mixture, when heated, disengaged volatile nitric acid, whilst the fixed phosphoric acid remained at the bottom of the retort. We shall soon see that things do not happen exactly in this manner: but before we prove this, it is necessary that we should give an account of what chemists have done respecting this action of the acids, between the epocha of the discovery of Scheele, and that of our own inquiry, the last that has been made to my knowledge upon this kind of analysis.

10. Poulletier de la Salle and Macquer first repeated, at Paris, Scheele's analysis of the calcined bones, and found it accurate with respect to the presence of the phosphoric acid in the bones, and the art of extracting phosphorus from them. Rouelle the younger, when he

also occupied himself with this subject, observed several important facts, and described them with much accuracy in the Journal de Medicine of the month of October, 1777. Such are, amongst others, 1. the means of separating carefully, by repeated decantations and filtrations, the sulphate of lime formed in the process of Scheele; 2. the examination of the liquor after evaporation, by osseous or calcareous nitrate, in order to ascertain the presence of the sulphuric acid in it by the precipitation; 3. the portion of salt thrown up and not volatilized in the distillation of this nitric and phosphoric liquor, by the jets formed in the thick liquid; 4. the decomposition of the sulphate of lime by the concentrated phosphoric acid; 5. the state of the opaque vitreous phosphoric mass remaining in the retort, and presenting a mixture of this acid, of the sulphuric, of base of bones or phosphate of lime, and of sulphate of lime; 6. the difficulty of separating the pure phosphoric acid from this mass; the means of effecting this separation by lixiviating, concentrating the lixivium by fire, and adding alcohol which precipitates the phosphoric acid in white flakes; 7. lastly, the fusion of this acid, thus prepared and purified into a very white and very transparent glass, and the positive proof that the earth dissolved by the nitric acid, and afterwards carried off by the sulphuric, is really calcareous: a proof which consists in precipitating it from the sulphate deposited

deposited by the carbonate of pot-ash, and calcining the precipitate in order to reduce it to the state of lime.

11. Citizen Nicolas, a chemist of Nancy, a short time after the inquiry of Rouelle, gave a new and much more simple process for extracting the phosphoric acid from bones; a process which contributed to elucidate their nature. Upon bones calcined to whiteness, pulverized, passed through the sieve, and placed in a vessel of stone-ware, an equal part of concentrated sulphuric acid is poured; the mixture is stirred with a spatula of glass; and a sufficient quantity of water is added to bring it to the consistence of thin soup. After some hours contact and repose, during which it thickens, the mixture is placed upon a double linen cloth suspended upon a square frame; it is washed with water till it ceases to be acid, and to precipitate lime-water, or till the water has dissolved all the phosphoric acid: the mixed water are evaporated, and by means of the filtre, the sulphate of lime is separated in silky straws or filaments, which are deposited during the evaporation, and must be well washed with a little water. This separation is continued till the liquor no longer deposits any thing; the concentration is then continued so far as to give the liquor the consistence of a soft extract: it is heated pretty strongly in a large crucible, in which it swells and exhales a sulphureous and aromatic smoke, in order either  
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to give it a semi-vitreous form, or even to vitrify it completely into a transparent glass without bubbles, which cannot be obtained except by keeping it fused for a sufficient time. If it be proposed to extract the phosphorus from it, the operation is continued only till it has the consistence of honey ; for the phosphoric glass does not afford this combustible body without great difficulty.

12. Since the publication of the process of Citizen Nicolas, chemists have all contented themselves with repeating it upon different kinds of bones, in order to compare them with one another, and to determine the quantity of phosphoric acid which each of them is able to yield. Berniard has thus compared fossil bones, those of the whale, of the elephant, the porpoise, of the bullock, of man, the horns of the elk, the teeth of the seal, ivory. Bullion has extracted it from the bones of fish and from ivory, from which Rouelle had said he was not able to obtain it. Citizen Vauquelin and myself, in our researches upon the animal matters, had occasion to examine with much attention the phosphoric acid extracted from bones, and to compare it with that produced by the deflagration of phosphorus ; from which it differs in some properties. We remarked that that of bones assumed by evaporation to a solid consistence, the form of pearly straws ; that when thus dried, it attracted the humidity of the atmosphere but very feebly ;  
that

that when fused into glass it was no longer acid, nor hardly soluble; we also found that the calcined bones, dissolved in the muriatic acid, afforded likewise, by spontaneous evaporation, 0,33 of scaly crystals, brilliant, acidulous, fusible into an insoluble glass, becoming very soluble by any acid, and especially by an excess of phosphoric acid; that is, in every respect similar to what is obtained from bones by the sulphuric acid. The nitric, the acetous and the acetic acids, &c. gave us a similar substance with the calcined bones. This matter, which reddens the blue colours, and is precipitable from its solution by ammonia, the caustic alkalis and lime water, into insipid and insoluble calcareous phosphate, presented us with all the properties of an acidulous phosphate of lime.

13. We found by these first experiments that the bones were not completely decomposed by the acids, though they all alike possess the property of softening them and dissolving their solid part; that their phosphate of lime was only in part decomposed; that the acids took from it only a portion of its base, and reduced it to the state of acidulous calcareous phosphate; and that there their action ceased. We afterwards found, by other experiments, that the acidulous phosphate of lime might also be prepared with the base of bones and the phosphoric acid; that this acid, when pure, decomposed the muriate, the nitrate and even the



the fulphate of lime, less indeed than the two first, and thus formed acidulous calcareous phosphate, always crystallizable into small brilliant and micaceous straws; that this acidulous phosphate contained 0,54 of phosphoric acid, and 0,46 of lime; whilst the phosphate of lime, of bones, or the well saturated phosphate, contained 0,41 of phosphoric acid, and 0,59 of lime; that in treating the latter by the acids, only 0,24 of lime was taken from it; that 100 parts of calcined bones, treated by the sulphuric acid were charged into 76 parts of acidulous phosphate, formed of phosphate of lime 59, and of phosphoric acid 17 parts; that there were only these 17 parts of free acid which afforded phosphorus in the distillation with charcoal; that the portion of neutral phosphate of lime remained in the residuum of this operation, and that it was on this account that from 100 parts of bones, according to the most exact calculations of Pelletier, who has given excellent details upon this preparation, only 0,05 of phosphorus, at most, were obtained; whereas the 100 parts of bone really contain 0,16 to the 0,41 of phosphoric acid which they contain.

14. This knowledge which we acquired concerning the semi-decomposition only of the osseous calcareous phosphate, by the acids, and the formation of an acidulous phosphate, afforded useful results for the extraction of the phos-

phosphoric acid of bones, their analysis, the preparation of phosphorus, and even for osteogeny.

Calculation and experiment have taught us that only  $\frac{2}{3}$  of their weight of concentrated sulphuric acid must be employed for decomposing the calcined bones, instead of  $\frac{3}{4}$  which chemists had directed.

In order completely to analyse the bones, and to ascertain the proportion of phosphoric acid and lime which they contain, after having dissolved their earthy base by any acid, as the nitric or the muriatic, this solution must be precipitated by the oxalic acid, which decomposes the acidulous phosphate of lime, like all the other calcareous salts, and consequently leaves the phosphoric acid nearly free in the liquor, swimming above the precipitate which it forms, which containing in 100 parts 0,48 of lime, thus indicates the quantity of this earth. No alkaline carbonate decomposes the acid phosphate of lime, nor consequently can they serve for this complete analysis.

As that which is obtained from bones treated with the sulphuric acid, yields phosphorus only in proportion to the excess of phosphoric acid in the acid phosphate of lime, if we treat the lixivium with nitrate or acetite of lead, we decompose completely, and by necessary double elective attraction, the acid phosphate of lime; all its phosphoric acid is deposited in union with the lead; all its  
lime

lime remains in solution, combined with the nitric or acetic acid. The precipitate well washed, and distilled with charcoal, affords a quantity of phosphorus, more than twice as large as the simple product of the evaporation of what was called *phosphoric acid of bones*; we thus obtain from 0,08 to 0,12, instead of 0,05, which had hitherto been extracted.

The very easy and abundant solubility of the osseous phosphate of lime in the phosphoric acid, and the speedy formation of acid calcareous phosphate, explain a series of important phenomena relative to osteogeny and the diseases of the bones, which are not to be detailed here, but which will be found elsewhere.

15. The caustic alkalies, and the alkaline carbonates have no action upon the osseous phosphate of lime, and do not effect any decomposition of it, though chemists have thought so, and have even proposed to fuse calcined bones with the carbonate of pot-ash, or of soda. It is a fact, of which Citizen Vauquelin and myself have well convinced ourselves, and which we have confirmed by very exact experiments. It will be seen hereafter that this impossibility of decomposing the phosphate of lime by the carbonate of pot-ash, either in the dry or in the humid way, opposed to the facility with which the oxalate of lime is decomposed by the same salt, has afforded much light respecting the analysis of several kinds

kinds of urinary concretions. The alkalies and their carbonates, in solution, act upon the gelatinous matter of the bones, which they thus soften, and the extraction of which they favour. No salt has any real action upon the osseous texture.

The metallic oxides, and their solutions in the acids, burn its membranous part more or less powerfully, or colour it, at the same time penetrating it, when they are diluted with water; in this manner it is that the solutions of copper turn the bones that are exposed to their contact green, and artificial turquoises are formed in pieces of bones, suspended in very weak nitrid acid, or even in other liquids, when only a mere pin of copper is at the same time immersed along with them.

16. Amongst the vegetable matters, if we except the acids already indicated, we know only the oils and some colouring matters that are capable of penetrating the osseous texture, undoubtedly in its gelatinous substance, and giving it either an unctuous flexibility, or a soft polish, or a more or less intense colour. It is known, relatively to this last mentioned fact, how easy it is to dye the osseous surface, and even to cause the colour to penetrate considerably between their deep-seated layers; and also how strongly the colouring matter adheres, and what liveliness it assumes in them, as is exemplified in the various toys of stained bones which are daily manufactured. We also see a striking  
proof

proof of this adhesion of the colouring matters with the bones in the brilliant rose-colour, which the bones of living animals contract from madder, mixed with their aliments. The fine tinge which this vegetable gives them seems to announce that its colour is brightened by an acid before it is deposited amongst the osseous laminæ.

Amongst animal matters, the fats and the coloured substances act like the preceding bodies upon the bones; the acids which are produced by the spontaneous alterations of these living matters, dissolve the phosphate of lime, and soften the osseous texture as easily as those which belong to the fossils or to the vegetable compounds.

17. The whole of the facts relative to the osseous texture prove that it is a compound of two principal substances, a gelatinous or glutinous base, and an insoluble salt. The first constitutes its true organic type; it is this which exists at first as membrane, as cartilage, and which gradually becomes filled by the progress of ossification in young animals, with small crystals of phosphate of lime which furnish its areolæ, and there assume the granulated, lamelated, cellular form, which is determined by that of these primitive areolæ, after the manner of a kind of mould. The first dissolves in water, is gradually decomposed, and leaves the bones brittle in proportion as its quantity diminishes. The other being soluble in all the acids which carry it off, reduces the bone in proportion as it is

is dissolved to its primitive cartilaginous or gelatinous nature. The one gives the primitive form, the pliability, the soft and polished texture. The other produces the solidity, the hardness, the resistance, and the permanent form. The first if it predominates, permits the bones to extend themselves, to form apophyses, sinuities, and depressions, by the attracting action of the muscles and the compressing action of the arteries &c. The second, when it comes to be predominant, opposes the change of form, renders the bones dry and brittle, frequently adds to their thickness, renders them deformed, enlarges them irregularly, and fills their cavities.

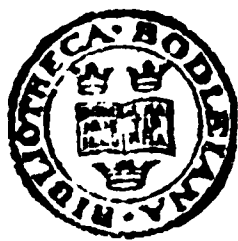
18. But though the general and in some sort common or average nature of the bones is at the present day well known; though their analysis throws some light upon their formation and the alterations of which they are susceptible; yet much still remains to be done, and what lights may we not expect from future labours and researches upon the bones of the fœtus compared with those of the adult and of old men; upon those of the different animals compared with the human bones, especially in the inferior orders of the amphibia and of the fishes, whose organs and functions, so different from those of man must produce such remarkable differences in the nature and composition of their parts. How many interesting facts will be presented to physiologists by a well conducted examination of bones that have  
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been

been buried for a longer or shorter time in the earth, exposed to the air or immersed in the water, and changed more or less considerably in their intimate nature, either by the subtraction of some of their constituent materials, or by the addition of some foreign matters.

19. A vast career is still open to chemists, if they choose to apply the means which they already possess to the highly interesting experiments upon ossification, and the regeneration of the bones, commenced under other relations by Duhamel, Fongerox, Haller and Troja; if they compare the progress of the formation and the solidification of these organs in the foetus and in the young animal, at different periods, with the quantity and the nature of its aliments; if by varying these, and adding to them substances which are known to influence the colour and the consistence of the bones, they follow with all the requisite attention the relations of both; if they multiply these useful experiments in animals of different orders, in the frugivorous and carnivorous mammalia, in the aquatic fowls and the birds of the forest, in the amphibia, and even in the fishes; if by laying bare the bones in some points in these living animals and enveloping the osseous parts with different substances, or with different elastic fluids, they thereby appreciate the influence of these contracts and the kind of alteration to which they give rise; if the external irritation and the destruction of the external periosteum, with the internal

ternal irritation and the disorganization of the marrow, be observed with care, and combined with the other modes of experimenting adopted by Duhamel and Fougereux.

20. The prospect enlarges and affords hopes of success still much more important than the preceding, when these exact analyses, these valuable researches shall have been extended to diseased bones, softened as it were, fused in the Rachitis, the lacteal affections, hardened and swelled in exostoses of different kinds, corroded and destroyed in different kinds of caries, dry or humid, slow or rapid; split, distended, inflated in the *spina ventosa*, the necrosis; re-formed, regenerated, doubled in the sequestra, fractures, callus. All these alterations so well described and known by the moderns, in which they have found subjects of observation which had escaped the ancient physicians, and views of treatment, with motives for prognosticating the cure which had been entirely neglected before; these cannot be really understood, nor their causes appreciated, their curative treatment rescued from the mere empiricism that has hitherto directed it, unless by positive experiments, well instituted analyses, for which the present state of chemistry presents means so new and so superior to those which the science formerly possessed.





## ARTICLE XIII.

*Of the Animal Matters contained in the Osseous Cavity of the Cranium, or proceeding from it.*

1. IN the twelve preceding articles, we have spoken of the different liquid and solid matters which are generally diffused throughout the whole body, and which constitute, as it were, its solid elements. In the present article we shall treat of the matters which are found in the cavity of the cranium. We shall not, however, speak of the membranes, the dura mater, the pia mater, and the arachnoid ; nor of the sanguineous vessels, as these bodies present nothing different from what has been set forth in general concerning the membranous and vascular texture, in one of the preceding articles. We shall treat of the cerebral matter, of the nervous fluid, of the liquor of the ventricles, and of the pineal concretions : these are in fact the four substances particularly contained in the cranium, and which, presenting an aspect, a structure, or physical properties different from these which occupy other cavities of the body, consequently deserve a particular examination. Two of these matters belong to the animal liquids, another to the soft part, and the last to the solids.

SECTION.

## SECTION I.

*Of the Cerebral and Nervous Pulp.*

2. THE brain, this viscus so regularly organized, and so voluminous in man, in whom it exceeds in weight the relative quantity contained in the cranium of any other animal, is furrowed at its surface into a multitude of grooves, elevated into protuberances at a number of points, presenting tortuous inequalities which have been compared to the intestinal circumvolutions, forming, at a small depth beneath this unequal and, as it were, carved surface, a homogeneous mass, of a grey colour externally, in its cortical layer, or cineritious substance, it is of a milk or ivory-white colour in its interior, presenting in its continuity an admirable series of forms, of colours, of protuberant, rounded, elongated parts, of cords, cavities, and tubercles, constant and regular in all individuals. This organ, which the anatomists, and especially Soemmering and Vicq-d'Azyr, have so well described, without however having been able to say any thing concerning the uses of all its very diversified parts; this anatomical and physiological enigma, which no naturalists has yet been able to unravel, represents a kind of thick paste, of a more or less

solid pulp, divided into the cerebrum properly so called, the cerebellum,, and medullary prolongations, which proceeding from these two centres, give rise to the medulla oblongata, to the pairs of nerves, and to the spinal marrow. The nerves which proceed from the base of this viscus, and those which pass from the spinal marrow to diffuse themselves throughout the whole body, and give it the cause of motion and sensation, are themselves real cerebral emanations, covered with membranes borrowed from the membranes of the medulla itself, from which they detach themselves, and relinquish them where they enter the parts to which they communicate the powers of motion and sensation.

3. The curious form and structure which this viscus exhibits, its size and quantity corresponding with the intellectual faculties of the animal, the senses which are contiguous to it, and, as it were, its nearest appendages, the internal sensation which apprises every one that the consciousness of his actions, his desires, his will, the exercise of all the faculties of his mind refer themselves to the interior of his head; the lesion of the function of the nerves, of motion, of sensation, even of thought, the madness, the fatuity which constantly accompany morbid changes produced around or in the interior of the cerebral texture, of whatever nature they may be; the lethargy, the imbecility, the fatuity, the idiotism, which are the consequences

consequences of pressure applied to these organs—all announce that the brain is the seat of the sensations, the sensorium commune, the grand focus of life, and the general source of the functions, which are called *animal* or *intellectual*. The anatomy of animals, pursued in all the orders of these organized beings, from man down to the testacea and worms, confirms this general notion, by showing the progressive degradation of the organization, of the mass, and of the different portions of this viscus, corresponding with a kind of striking precision with the diminution of sensibility, of intelligence, of instinct, and of sensitive organs in these beings.

4. Incomprehensible to the most able anatomists, who have best understood and demonstrated its numerous circumvolutions, its most hidden structure, its most delicate parts, this viscus presents no more hold, or rather it affords no more satisfactory results to the chemist than to the physiologist, who has examined only its structure. The one, after the most persevering labours, is no less astonished than the other, at the small degree of relation which he finds between his result and the properties of this living organ. Few learned men have yet occupied themselves with the analysis of the cerebral pulp, or medulla; and, before the most modern times, they had not even the curiosity to attempt to investigate its nature and composition; there were scarcely more than a few facts, borrowed

borrowed from the art of cookery, or observed in the processes employed by anatomists for demonstrating the different parts of the brain, that had afforded a superficial notion of its chemical properties. Garman had announced its singular preservation in the osseous cranium of buried bodies. Burrhus had compared its texture with an oil, and had even considered it as approaching to the nature of spermaceti. Citizen Thouret first described a series of experiments upon the nature of the medulla of the brain, in a Memoir published amongst those of the Society of Medicine, and represented it as a kind of saponaceous substance, composed of an oil and fixed alkali. I published, in March, 1793, in the *Annales de Chimie*, tom. XVI. an analysis of the human brain, and of that of several of the mammalia, of which I shall here present a notice.

5. The human brain, which I shall take as the example and type, fresh and cut into slices, placed in a flask with a tube, immersed under a bell glass full of water, at 20 degrees of temperature, give out at first some bubbles of carbonic acid, but it afterwards presented no gas during more than a year; it exhaled a bad smell without experiencing any real fermentation, or very perceptible alteration in its substance, &c.

Exposed to the air, at a temperature exceeding 12 degrees, the brain becomes very fetid, assumes a green colour, putrefies, but nevertheless

thelefs acquires acidity, and reddens blue paper.

Dried on the water-bath it first coagulates, a small quantity of water is separated from it, and it diminishes from  $\frac{4}{5}$  to  $\frac{2}{8}$ ; it grows less, becomes yellow; it kneads and balls under the fingers. When afterwards strongly heated in an earthen crucible, it exhales ammonia, softens, swells, becomes brown and black, melts, diffuses thick and acrid fumes, inflames, remains for a long time ignited after the diminution and cessation of its flame; it then affords sulphureous acids, produced by the combustion of the small quantity of sulphur which it contains, melts in this seemingly coally state, acquires a ropy liquidity, becomes fixed into a sort of blackish and brittle bitumen, and affords no trace of alkali in its lixiviated coal. When the dried brain is treated in the retort, we obtain from it water charged with several ammoniacal salts, a considerable abundance of oil, concrete carbonate of ammonia, carbonated and sulphurated hydrogen gas, and carbonic acid. We find some traces of phosphates of lime and of soda, but no free in its coal.

6. The cerebral pulp diluted with water, and suspended in it like a thick emulsion, is coagulated by heat, and separates into flakes like milk treated with an acid. The liquor, separated from the flakes, is precipitated by lime-water and by the calcareous salts; it becomes coloured as it evaporates; it affords phosphate  
1 of

of soda by crystallization. All the brains of the mammalia and birds present the same character of being diluted in water by trituration, and separating from it in coagulated flakes by the action of heat. This viscus and glairy solution froths by agitation, and resembles a strong ley of soap so nearly, that it might be mistaken for it by its appearance. A part of this cerebral matter suspended in the emulsive form, swims like a kind of cream at the surface of the liquor. Alcohol coagulates and precipitates, in condensed flakes, the matter of the brain thus diluted and suspended in water. It is also to be observed, that this liquor, of an emulsive or saponaceous appearance, does not alter the vegetable colours; the acids decompose and coagulate it. The cerebral pulp, ever after its coction, and the kind of hardness of coagulation, which it experiences to dryness, when heated on the water-bath, after having suffered a portion of this liquid to escape, and having assumed, in the kind of dryness which it acquires, a fawn-colour, whilst it is reduced to a fourth or fifth of its primitive weight, has not lost all its attraction for water; it may still be diluted in it by mere trituration, and presents a yellowish emulsive liquor, which indeed is quickly decomposed, throws down flakes of hardened pulp, and retain only some soluble salts.

7. The brain dried, baked, and even beginning to roast, in the manner of those vegetable sub-

substances from which oil is obtained by pressure, being placed between two hot plates of iron, and subjected to the action of a press with a lever a metre in length, and moved by two men, did not yield a single drop of liquid oil. This experiment, indicated by Burrhus, who asserted that he had extracted a concrescible oil, from the dried brain, had no success; and there is reason to believe, that this author employed brain already altered, either by time, or by the processes to which he had first subjected it. This property of affording a concrete oil, or rather of having almost its whole mass converted into a concrescible oil, analogous to spermaceti, is however acquired by the cerebral pulp, by means of the gradual putrid decomposition which it undergoes in buried bodies. This is one of the curious observations that were made by Citizen Thouret and myself upon the bodies with which the ground of the burying place of the Innocents in Paris, was filled to a great depth. They all presented in their cranium the mass of the brain lessened, contracted, occupying not more than from a tenth to a fifteenth of the volume of this cavity, frequently moving freely within it, of a much firmer consistence than in its natural state, of a blackish or dark-brown colour in its interior part. This pulp, thus dried and hardened, presenting no longer either the external form or the internal appearance of the brain from which it had its origin, was brittle, softened under



under the finger, was diffusible in water, exhaling a faint disagreeable smell, and presented all the characters of an ammoniacal soap. It afforded by the acids which decomposed it a thick, fatty, oily, fusible precipitate, which became fixed into crystalline laminæ by cooling, was soluble in alcohol, and in short, possessed many properties analogous to spermaceti. But it is very evident that this oily matter does not exist ready formed in the brain, and that it is the product of a septic alteration, which announces indeed, in the cerebral pulp, a greater disposition than in many other animal substances to acquire this form and this character of an adipocirous oil.

8. The cerebral pulp being diluted in water, and mixed with sulphuric acid, coagulates into flakes, which may easily be separated from it and obtained upon the filtre. The filtrated liquor contains a small quantity of animal oil, which burns, is decomposed, and precipitates carbon by the progress of the evaporation. We find in it lime, soda, ammonia, united either in part or wholly with the sulphuric acid that has been added, and free phosphoric acid. The coagulated matter does not present the oily characters, but those of a concrete albumen.

Weak nitric acid decomposes the brain in the same manner; the concentrated nitric acid immediately coagulates it, disengaging from it azotic gas, produces considerable effervescence, and foam, almost produces

duces inflammation. It leaves to a coally, swelled and voluminous matter, and exhales a mixture of nitrous gas, carbonic acid gas, and ammoniacal gas. We find phosphate of lime, oxalate of lime, and oxalate of soda in the ley, and in the ashes of the coal obtained by this experiment.

Muriatic acid poured upon the human brain, diluted in water, separates from it coagulated flakes which swim at the surface. The liquor cleared by repose, and separated from the coagulum by the filtre, being evaporated by a gentle heat, affords transparent pellicles which blacken at the end of the operation: we extract from it by the same evaporation, and by absorbing the excess of acid by means of ammonia, soda, lime, and phosphoric acid, united partly with each other, and partly with the muriatic acid. The coagulated and dried part is about a tenth or twelfth of the original weight of the brain employed; it presents all the properties of a concrete albuminous matter.

9. The leys of caustic fixed alkalis act powerfully upon the cerebral pulp. This action takes place even in the cold: much caloric and ammonia are disengaged. This last effect, which is observed even upon fresh brains, presents itself even with such as are already acrid. The medullary pulp becomes greyish, and sometimes of a light rose colour. When its solution is effected by heat, it comports itself like a soap. This effect resembles what has been stated elsewhere

where concerning the action of the alkalis upon the animal substances in general, and it depends upon the alteration which the albuminous cerebral substance experiences at the very moment of the mixture. The opposite effects of oils heated with the substance of the brain is sufficiently known, as this is an experiment which is constantly made in boiling and frying this alimentary substance in oil; one part, nearly the half, dissolves and gives to the fixed oil a pretty strong consistence: the other dries, contracts, coagulates, bakes, and assumes a density, an agreeable taste, with an insolubility which it did not possess before.

10. The action of alcohol upon the cerebral pulp, deprived of a great part of its water by desiccation, is one of the most singular phenomena which this substance has presented to me. When treated four times in succession with twice its weight of well rectified alcohol, and by an ebullition of a quarter of an hour each time, in a matrafs with a long neck provided with a grooved stopper, in order that as little alcohol as possible may be lost, the three first portions of alcohol decanted boiling, deposited by cooling brilliant laminæ of a yellowish white colour, less in quantity each time; the fourth scarcely deposited any thing. The cerebral matter lost  $\frac{4}{5}$  of its weight; and I obtained in all, by the spontaneous deposition and by the total evaporation of the alcohol,  $\frac{3}{4}$  and a half of needled crystals, of large plates,  
or

or of granulated or more condensed matter. There were, as is evident,  $\frac{2}{3}$  and a half lost in water volatilized with the alcohol. This crystallized substance, of a fatty appearance, became agglutinated into a paste under the finger; it did not melt in the heat of boiling water, but was merely softened. At a higher temperature, it suddenly acquired a blackish-yellow colour, and exhaled during its fusion an empyreumatic and ammoniacal odour. It had therefore no real analogy with spermaceti, which melts between 32 and 35 degrees, nor with the fat matter of putrefied bodies, which melts at 28 degrees; it seems more to resemble the fat lamellated crystals contained in the biliary calculi, which do not soften even at 90 degrees of Reaumur's scale. This latter substance does not become either ammoniacal or empyreumatic at this temperature, like the crystalline cerebral oil extracted by alcohol.

11. I must here observe that the portion of this concrete oil, separated from the alcohol which had dissolved it by evaporation in the sun, and which had formed itself into a granulated pellicle at its surface, in consequence of the particles being rapidly attracted towards those placed in the centre; presented some properties modified in a different manner from those of the portion of the same oil deposited spontaneously by the cooling of this alcoholic solution. It was a little more abundant than the first, of a deeper yellow colour, having a very marked  
smell

## SECTION II.

*Of the Nervous Fluid.*

13. MOST physiologists admit a very light and very moveable fluid, almost to be compared with the electric or magnetic fluid, which they believe to flow by the impulse of the will or of any irritation from within the brain, or the cerebellum, or the medulla oblongata, or the spinal marrow into the nerves; and the use of which they consider to be that of conveying the cause of motion and sensation. They cannot, however, give any other proofs of its existence than the diminution or cessation of the nervous action in consequence of ligatures applied to the nerves, or of a compression which they imagine must impede or stop the motion of this fluid. There is no cavity in the nervous chords; we see in them no other matter than the medulla which occupies their centre, and a mucous liquor which moistens their membranes. This difficulty vanishes with those who represent this fluid as possessing a tenuity superior to that which is known in any of the visible animal fluids: it not only escapes our senses, but the imagination itself can scarcely comprehend its velocity.

14. In

14. In admitting this fluid, it must be supposed to have either two opposite kinds of motion, which is difficult to be conceived in the same nerves; or else two kinds of nervous channels, the one carrying the sensitive fluid from the organs of the senses affected from without into the brain, the seat of the *sensorium commune*, the others conveying it from the brain into the viscera and the muscles, in order to carry into them the principle of life and of independent motion, which is supported in the former, and the command of the will which solicits and provokes it in the latter. It must moreover be admitted, that this nervous fluid can follow only a single course, whether in one or in the other of these channels, for it cannot return against itself, and consequently, it would appear to be dissipated after its effect has been produced, which accords with its extreme tenuity and the great velocity of its motion. It is undoubtedly on account of these difficulties that some physiologists have denied the existence of that fluid which others had called *animal spirits*, and that they have thought they could explain the functions which were attributed to it, either by a rapid impulse communicated to an uninterrupted globular texture in the brain and the nerves, or by a vibration excited on the filaments of those organs. In fact, these two hypotheses are attended with no less difficulty than that of the existence of a fluid, since they suppose a tension, a rigidity, or solidity in

the nervous fibres, which the most simple observation leads us to reject.

15. No experiment, nor fact, can throw the smallest light upon or give the most simple notion of the nature of the nervous fluid. It is entirely and perfectly unknown to those who admit it, and who have no doubt of its existence. It has been supposed to be the same with the electric fluid, but the nerves exhibit no sign of electricity; and though some experiments seem to prove, that after death they are very good electric conductors, none can lead us even to suspect its existence in the nervous system, and its passage, as well as its accumulation in the different regions of that system. To admit, since the discovery of Galvani respecting metallic irritation, a particular fluid different from the preceding, of which the brain should be the reservoir, and the nerves its different ducts, would be the fabrication of an hypothesis destined to be incessantly overturned by new researches. Some have supposed the nervous fluid to be a gas, more especially oxygen gas; but it would require hollow tubes to conduct it, and nothing of this kind is known either in the brain or in the nerves. It must therefore be admitted, that we are absolutely ignorant of what the nervous fluid may be, as well as of the general mode in which the action of the brain and of the nerves consists.

## SECTION III.

*Of the Fluid of the Ventricles of the Brain.*

16. IN the ventricles of the brain, as well as between its membranes and its surface, is found a slightly viscous fluid, which incessantly exudes from the arterial extremities, which lubricates and softens the surfaces between which it exists, and prevents them from forming adhesions with each other, as is also found in all the other cavities between the surfaces of the membranes of the body. Authors improperly call it a vapour. It is incessantly sucked up by the absorbent vessels, or by the veins. It sometimes accumulates and forms dropsies of the head of different kinds. A similar liquid exists in the middle cavity of the spinal marrow and between its membranes. This humour does not appear to differ from that which lubricates all the membranous cavities of the human body in general, and of which I have already spoken. It is a muco-gelatinous liquid, more or less albuminous, and containing some saline matters. It is the same matter which filtrates between the fibrous fasciculi of the cerebral medulla, and renders them soft and pulpy.



## SECTION IV.

*Of the Pineal Concretions.*

17. EVERY anatomist knows that the pineal gland, the uses of which are absolutely unknown, frequently contains in the interior of its pulp, two or three small hard concretions, which are found in it by crushing this glandular body between the fingers. These concretions are so common, that very few brains are opened in the anatomical theatres in which they are not met with. They are generally so small and so light, that it is necessary to collect several of them together, in order to be able to examine them. About twenty of them are required to form a gramme. They are irregularly rounded bodies, with asperities and points at their surface, never smooth and polished. I have found them to be composed of phosphate of lime united to about one third of their weight of gelatinous matter. As the calculi of the pineal gland are so frequent in the human brain, and as they do not appear to produce diseases, they may be considered almost in the light of natural concretions, or depositions, the formation of which, in this single region of the brain, is indeed a singular phenomenon, the cause of which deserves to be investigated by anatomists.

## ARTICLE XIV.

*Of the Liquids peculiar to the Eye; of the aqueous, vitreous and crystalline Humours, and of the Tears.*

1. THOUGH I here indicate in particular, as humours of the eye, those only which are known by the name of aqueous, vitreous, and crystalline humours, and tears; this admirable organ contains also several other liquid, soft, or solid substances, which would deserve a particular examination, but with which chemistry has not yet been occupied. We are entirely ignorant of the nature of the black *pigmentum*; of the choroid, which appears to be carbon; of the soft and transparent pulp of the retina, the principal seat of vision, and which is certainly not a simple albuminous humour, as its aspect seems to announce; of those hard and thin membranes which form the shell of the eye; of that brilliant, pearly, gold-coloured lining which invests the internal surface of the globe of the eye. We have scarcely yet occupied ourselves, or to speak more properly, we have as yet only some preliminary, and as it were provisional notions of the vitreous, aqueous, and crystalline humours, according to the experiments of Petit and Chrouet, who have published a Dissertation

tation upon the humours of the eye. The tears are a little better known.

2. The aqueous humour is contained, in the proportion of from a quarter to a third of a gramme, in the two chambers of the eye, the anterior and the posterior, between the surface of the transparent cornea and the crystalline humour. It is separated by the arteries of the ciliary process and of the iris; it runs out in part by the pores of the cornea, where it is taken up again by the absorbent vessels. Its renovation is so prompt, that after it has been evacuated in the operation of the cataract by the aperture made in the cornea, it is renewed and distends this membrane within twenty-four or thirty-six hours. Halloran has seen a gramme and one-third of it flow in twelve minutes from a wound in the eye. Bertrandi thought it was lighter than water, in the proportion of 975 to 1000; but there is reason to believe that this is an error. It is perfectly transparent, has a slightly saline taste, and a very great liquidity. It evaporates entirely and without residue. The acids and alcohol do not effect its coagulation; the nitric acid, the nitro-muriatic acid, and especially the oxygenated muriatic acid, have the property of rendering it a little turbid. Though little charged with animal matter, it putrefies and exhales a bad smell. We find in it also some traces of alkaline phosphates, of soda, and of muriate of soda. Its use is to distend the cornea and support its rounded form,  
and

and retain the crystalline and the vitreous humours in their position. It sometimes accumulates to such a degree as to push the cornea before it in a hideous manner in the hydrophthalmia: it is seemingly gelatinous in the tortoise and in some fishes.

3. Scarcely any thing has yet been said concerning the nature or the composition of the vitreous humour; it derives its name from its transparency and its aspect, which resembles melted glass. Inclosed in membranes, or very close membranous cells, it occupies all the bottom of the globe of the eye from the posterior surface of the crystalline to the surface of the retina; it is slightly reddish in the foetus, and is never known to become opaque in old age. The exact degree of its density is not known; but it is known to be superior to that of the aqueous humour, and inferior to that of the cornea. Wintringham found it relatively to water, as 10024 to 10000. Its quantity is considerable, for, according to Petit, who has given both in the Memoirs of the Academy of Sciences, of Paris, for 1728, and in particular letters, an exact description of the parts and of the humours of the eye, it constitutes of itself more than two-thirds of the weight. Some of its chemical properties have been indicated by Petit, Chrouet, Mauchart, and Zinn. It does not coagulate in boiling water; it is evaporated entirely by the fire; it contains but very little salt and earth; the powerful acids and the fixed  
alkalis

alkalis render it a little turbid. It becomes glutinous, thick, even concrete, and more or less opaque in some diseases, especially in the glaucoma. Duhamel saw it once sensibly reddened in an animal to which he administered madder.

Boerhaave observed already long ago, that a wound made into the vitreous substance suffered the humour of this substance to run out only in a successive, gradual manner, drop by drop, whence he concluded that this humour was contained in numerous cells communicating with each other, narrower in the interior and wider at the outer part of this body, to which its apparent viscosity is owing; for when we suspend a vitreous humour by a thread over a vessel, in proportion as the humour runs out, the small divisions of the membrane contract, disappear by approaching each other, and the liquid collected is as thin and as fluid as water.

4. The crystalline lens, seated in the anterior fossa of the vitreous substance, and inclosed in its particular capsule, is an almost solid or semi-concrete body, like a very thick jelly, of a lenticular form, the form, the curvature, and the internal structure of which have been carefully investigated and described. It has a diameter of about four lines in man, and the average amount of its weight is a quarter of a gramme. It is heavier than water, and sinks to the bottom of this liquid. Very soft in the foetus, it grows hard in old persons, and by the progress

progress of age it gradually passes from a perfectly colourless and transparent state into a yellowish colour, like topaz or amber, with a slight obscurity. It is very easy to be cut or divided; pressure bruises and extends it, and separates the greater part of its particles.

It has long been known that it is susceptible of becoming opaque, cartilaginous, osseous, and even of an almost stony hardness. The example of fried fishes shows us that the crystalline lens becomes concrete by the action of heat; that it is rendered white and friable, like a kind of soft plaster; that it separates into concentric plates, which are easily divided into a hundred; and that these plates are formed of fibres intertwisted, or rolled up in spiral windings.

Chrouet, in his history of the humours of the eye, assures us that the crystalline affords oil and ammoniacal spirit in great abundance by the action of fire. Twenty-four grammes of this body distilled, afforded him two grammes and a quarter of insipid water, eight grammes of ammoniacal water, a third of a gramme of concrete carbonate of ammonia, a little less than three grammes of very fetid oil, and eight grammes of coal, the incineration of which left a gramme and a half of ashes without fixed salt or alkali.

The crystalline becomes opaque by coction in boiling water, by the action of the acids, and by alcohol. It seems to be formed of a thick, albuminous

albuminous and concrescible matter with a portion of gelatin. No exact analysis has yet been made of it.

5. The tears are secreted by a conglomerate gland, situated in a depression at the external and superior angle of the orbit, and they are discharged by six or seven open ducts in the conjuction over the margin of the upper eyelid, whence they flow along the eye towards the puncta lacrymalia. They have not been the object of a connected series of researches. They had been represented as a rather saline aqueous liquor, affording scarcely any residuum by evaporation; and Pierre Petit, in his curious treatise on the tears, being intirely occupied with their origin and their relations with the passions, had scarcely said any thing concerning their nature. The illustrious Haller complained of this want of facts in his great physiological work; he contented himself with quoting some rare examples of saline crystals which they had exhibited to Bruckman, of those of an austere acid taste, which Schaper had observed in an ophthalmia of the blood which frequently is mixed with them, of the sweet quality which had been found in them in some diseases. Several fortunate opportunities for procuring them having presented themselves to Citizen Vauquelin and myself, in 1791, we made them the particular object of our researches; and we have published upon the Analysis of this humour, in the  
Annales

*Annales de Chemie*, for August of the same year, a Memoir of which I am now about to present the results.

6. We procured tears in sufficient abundance to be able to make them the subject of our experiments, either from persons subject to weeping, who consented to collect them in small glass vessels, or by causing them to flow in unusual abundance, by means of mechanical irritation applied to the nostrils, or by the effect of cold, which increases their discharge in some individuals. This humour is as clear as water, without smell, of a saline taste, and of a weight little superior to that of distilled water. It turns the paper tinged with mallows or violets green, without this colour being dissipated in the air; a proof that it proceeds from the action of a fixed alkali. When heated, it presents at its surface many permanent bubbles, like a mucous liquor; evaporated to dryness, it leaves at most 0,04 of a dry and yellowish residuum of an acrid taste. In close vessels it affords much water, some traces of oil and of ammonia, and a very saline coal. The incineration of the product of the spontaneous evaporation exhibited to us muriate of soda, carbonate of soda, very little phosphate of soda and phosphate of lime.

7. Tears exposed to hot and dry air, in a flat vessel, become thick pretty quickly; they become viscid and stringy, without losing their transparency; assuming a yellowish and sometimes



times a green colour. They afford cubic crystals, which alcohol dissolves without attacking the mucous and thick part; these crystals turn paper stained with mallows green, and announce an excess of alkali. Water which dissolves immediately, in every proportion, and dilutes the lacrymal humour in its natural state, does not operate in the same manner upon this humour when thickened and become stringy by exposure to the air. It remains suspended in the water like a glairy matter, or else dissolves very slowly; for the water froths by agitation, after having remained a long time upon this matter. This is an instance in which the contact of the air deprives an animal matter of its solubility in water.

The alkaline solutions, which have no sensible action upon the pure tears, quickly dissolve tears that have been thickened by exposure to the air, and restore them to their original fluidity and transparency.

Lime-water, the solutions of barites and of strontian, produce no effect upon the tears at the moment of their discharge; but when they have been for some time exposed to the air, they render these liquors turbid, and afford very sensible precipitates of earthy carbonates. This phenomenon proceeds from the circumstance that the tears contain a small quantity of pure soda, which attracting the atmospherical carbonic acid, and passing gradually by the contact of the air into the state of alkaline carbonate, becomes

comes thus susceptible of being decomposed by the solutions of the three earths, whose attraction for carbonic acid is stronger than that of the soda. Alcohol forms very sensible white flakes in the tears, and retains the most of their salts in solution.

8. No acid has any action upon the tears at the moment of their discharge, when they have not yet experienced any alteration. No other change takes place in them, than the saturation of the soda which they contain: so that the smallest quantity of acid is sufficient to prevent their turning the mallows-paper green. The residuum of their spontaneous evaporation comports itself differently with the acids. A drop of concentrated sulphuric acid thrown upon this residuum produces a very sensible effervescence, accompanied with a white vapour; muriatic acid and carbonic acid are disengaged at the same time, which announces the decomposition of the muriate of soda contained in this fluid, and of the carbonate of soda which is formed in it by exposure to the air. The muriate and acetous acids, on the contrary, produce only a slight effervescence with this spontaneous residuum of the tears, because they decompose only the carbonate of soda, and disengage only the carbonic acid.

9. The oxygenated muriatic acid is one of the re-agents that have given us the most light respecting the nature of the tears. We already know

know from a fact, which cannot escape our observation in active laboratories, that the contact of the oxygenated muriatic gas thickens the lacrymal humours to such a degree, as to render the motion of the eye-lids upon the ball of the eye difficult and painful. When liquid oxygenated muriatic acid is poured upon tears at the moment when they have been discharged from the eye, a slight coagulation takes place in this liquid; flakes are precipitated, at first white, which are quickly turned yellow by a larger proportion of acid. In proportion as they are formed, the oxygenated muriatic acid loses its harsh smell; whence we see that it yields its oxygen to the animal matter. It cannot be doubted, that what here takes place rapidly, is effected in a gradual manner upon the tears by the contact of the air; that in both cases the fixation of the atmospheric oxygen is alone to be considered as the cause of the thickening and the formation of a white and seemingly puriform matter, which takes place in the nasal sac, when the tears remain in it, obstructed by any impediment. A slight compression, to the application of which persons subject to obstructions of this sac are incited by an itching sensation, causes this thick yellowish matter to issue out from the puncta lacrymalia, in small cylinders or elongated drops, more or less solid, moulded by the branches of the lacrymal syphons. We must add indeed to this action of the atmospheric oxygen, the evaporation of

the water as a cause of this thickening; for we were convinced by a subject afflicted with an obstruction of the nasal sac, that he could extract four times as much humour from this distended sac by pressing it out every hour, than by soliciting its discharge every four hours. The same inspissation, proceeding from the absorption of the air by the tears and the evaporation of their water, gives rise to those small clots of thick, yellowish, and concrete humour, which are formed during sleep, round the lacrymal caruncles.

10. It results from this analysis that the tears are formed of a large quantity of water, which holds in its solution an animal mucilage, not albuminous, because the simple acids do not coagulate it, but of a gelatinous nature, and several saline substances, muriate of soda, pure soda, phosphate of soda, and phosphate of lime. The two last are less perceptible than the two first. One of the characters that most eminently distinguish this animal matter, is the property which it possesses of rapidly absorbing oxygen, and of forming thick, concrete, insoluble flakes. Though it contains the muriate and the phosphate of soda in but small quantity, the first is nevertheless sufficient to give this humour a saline taste, and enable it to deposit some saline crystals on the outside of its ducts, as some rare observations have shown.

The phosphate of lime, of which we have found only some slight indications in the tears, may,

may, it appears, increase in its proportion under certain circumstances, and separate in the solid form: it is this which gives rise to the calculous concretions which are sometimes formed in the lacrymal glands, and are even deposited in small separate grains round this gland. I have twice had occasion to analyse this concretion, and have found its solid base to be calcareous phosphate.

#### ARTICLE XV.

##### *Of the Nasal Mucus*

1. THE name of *nasal mucus*, is given to a liquid which is secreted in the cavities of the nose, and is discharged outwardly, either by the nostrils in the form of drops, or in that of masses more or less thick and viscid, or by the fauces, when it descends by the posterior part of the nasal cavities in which case it is thrown out by hawking and spitting. This liquid is separated from the blood by the arteries, with which the whole schneiderian membrane is provided, and appears to be formed in particular glandular crypts, which we find abundantly disseminated in the nostrils; it is collected also from all the frontal sinuses, from those of the ethmoid, of the sphenoid and of the superior maxillary bones, upon the membranous sides  
of

of which we see no glanduliform crypts. It is also mixed with the lacrymal juice, which descends by the channel which passes through the os unguis, and dilutes the thickened nasal mucus.

2. We must particularly consider both the abundance and the characters of this liquid in the catarrh, improperly called catarrh of the brain, in which the nasal mucus is separated in larger quantity, and remains a longer time in its ducts. It is especially under this circumstance that Citizen Vauquelin and myself have examined it, as we then procured it with great facility. We have also availed ourselves of the considerable discharge of mucus which is produced by the contact of the oxygenated muriatic acid gas, in order to obtain a sufficient quantity of it for the experiments adapted for making us well acquainted with its nature. It has several times happened to Citizen Vauquelin, who is very sensible to the action of the oxygenated muriatic acid gas, that he has collected by its effect sixty-four grammes of this liquid in less than an hour. By means of these circumstances we have been enabled to determine its nature in a considerably exact manner. It is known that this liquid is very abundant in children, that it is a little heavier than water, and adheres to most bodies, even the most polished.

3. The nasal mucus is at first liquid, clear and limpid, a little viscid and adhesive, without

smell, of a saline and acrid taste, which irritates the most delicate part of the skin: it is then really the pituita vitrea of the ancients. When exposed to the air and to the fire, it comports itself in the same manner as the tears, from which it differs only by the abundance of its residuum which is thicker, and frequently more coloured. It affords crystals of muriate of soda, of soda in the state of carbonate and of phosphates of lime and of soda; the last are much more abundant than the others. It turns paper stained with mallow-flowers green, by its salts; we also find in it an animal matter which is not albuminous, but quickly becomes thick and concrete by the oxygen of the air and of the oxygenated muriatic acid; it then acquires opacity, and a yellow or greenish colour, swells considerably, and becomes filled with bubbles by the action of fire, leaving but little residuum upon the ignited coals. This animal mucilage, which is more abundant than in the tears, appears to be of the same nature-in both.

4. This liquid, being always exposed to the air which continually passes through the nostrils, is constantly thicker, more viscid and more adhesive than the tears; and the carbonate of soda which it contains, whilst the latter contain only soda, announces that the air deposits in it a part of the carbonic acid which it contains, especially as it is expired out of the lungs. Consequently, it then renders the solutions of barites, of strontian,

frontian, and of lime, very sensibly turbid. In the nostrils, the heat of the plant, especially in catarrhs, and the current of air which incessantly acts upon it, contribute also to thicken it. The mucilage of the nasal humour, when it becomes thick in the air, frequently assumes in it the form of small, dry brilliant, and as it were, micaceous plates. If it has dried in very thin layers, it nearly resembles those brilliant and light marks which snails leave behind them upon the substances over which they crawl. The nasal mucus experiences no real putrefaction in the air; we should almost be induced to say that it was unalterable and imputrescible, when we see it remain without contracting any bad smell, even in the midst of water, and at a considerably elevated temperature. However, this property of preservation does not extend so far as to communicate itself to other bodies that are immersed in it.

5. Water does not dissolve the mucus of the nose. It is known that this matter remains viscid in that fluid, and that it cannot be diluted with water without much difficulty, even by agitation. Hot water and ebullition do not render this singular mixture more miscible or more soluble. In boiling water, it appears at first to form one body with the water; nevertheless we see it separate and fall to the bottom of this liquid by cooling. It is probable that this insolubility is owing to the fixation of the oxygen. Neither has it the property of ren-



dering oils miscible with water, nor of effecting their suspension by trituration, as a vegetable mucilage does. It is on this account that when we wash, or even boil this thick humour in water, the salts which it contains are dissolved and separated, without affecting the mucilage which constitutes its base.

6. The acids thicken the nasal mucus when they are concentrated and employed in small proportions; but when we add a larger quantity, they re-dissolve and give it different shades of colour. The sulphuric acid tinges it purple, and renders it very liquid, forming however some flakes in it which sink to the bottom. The nitric acid, when rather strong dissolves it of a yellow colour. The muriatic acid is that which effects its solution the most easily and the most completely of all, giving it a violet colour. The alkaline or earthy salts do not cause it to undergo any alteration, nor do they dissolve it.

7. The mucus of the nostrils being especially distinguished from all the other animal liquids by the viscid mucilage which it contains in considerable abundance, it is evidently from the presence of this principle that we ought to seek its uses and the function which it performs in the animal economy. Besides the kind of evacuation, sometimes very abundant, which it procures, and the proportion of the evacuated matter compared with that of the other excretory organs, which it carries out of the body, this  
liquid

liquid maintains the softness of the membranous sides of the nasal cavities and prevents that dryness which the air passing in continual streams through these cavities tends to produce in them. It moderates the too great sensibility of the nervous papillæ which are spread out upon the olfactory membrane; it stops and fixes the odorous bodies, it blunts their too great activity; it purifies the air that is respired, by taking from it the pulverulent particles which it carries along with it, and which would be more hurtful in the lungs. Being always contained in a hot humid, and arid place, three circumstances which would so eminently promote putrefaction, provident nature has given it a property which opposes the septicity which would have exposed man and the animals to a multitude of dangerous vitiations and maladies.

8. It is known that the mucus of the nostrils is capable of changing its nature and assuming various properties in the nasal affections. It thickens, becomes yellow, orange-coloured, or greenish, frequently tinges linen with a very lively green cast by drying upon it; it sometimes produces the sensation of the presence of copper; and sometimes it exhales a nauseous or fetid smell. In some affections it becomes so acrid that it seems to corrode the membrane of the nostrils, and produces excoriation round their orifices as well as upon the upper lip. Lastly, it is sometimes liquid like water, at others ropy like oil; in several cases thick, viscid,

viscid, and always transparent like jelly ; in other circumstances, semi-concrete and white, yellow or green, like a purulent humour. None of these changes have yet been chemically examined, and hardly even has the attention which they deserve been bestowed upon them.

9. Citizen Vauquelin and myself have described with much care the effect which the oxygenated muriatic acid gas produces upon the nasal mucus and upon the membranes which it covers and from which it filtrates. At the very moment when this gas penetrates into the nostrils, it produces in them a sensation of contraction and of uneasiness, of which sneezing is the consequence ; a considerable discharge of clear liquid is excited. The contraction and the rigidity of the membranes of the nose and of the throat remain for a long time : after the cessation or diminution of the first discharge, follows an uneasiness and stuffing of the nose, and the senses of smell and taste are lost. An humour, thick, and even dry like parchment, is felt in the nose and in the fauces : an acrid heat propagates itself into the breast and produces a febrile commotion : a considerably violent head-ache, and confusion of intellect accompany this state. At last white or yellow concrete masses are discharged by the nostrils or the mouth, the discharge of which lasts several hours, procures relief, and the malady gradually ceases till the equilibrium is intirely re-established. It

cannot be doubted that this artificial disease has a great analogy with the natural catarrh, and that in the production of that disease the atmospheric oxygen exerts an action similar (excepting that its intensity is less) to that of the oxygenated muriatic acid. In the sudden sharp frosts which are perceived by a harsh rough sensation, this principle of the atmosphere acts very quickly upon the nasal mucus ; it thickens it by depriving it of water and becoming itself fixed ; it irritates the surface of the schneiderian membrane ; it evaporates, in the compound ratio of its motion and its density, a large quantity of water. This explanation of a natural fact, to which we have been conducted by a phenomenon created by art, shows what may be hoped from the researches of modern chemistry, and how important it is to pursue them without intermission.

## ARTICLE XVI.

*Of the Mucous Humour of the Mouth, of the Humour of the Tonsils, of the Saliva, of the Salivary Calculus, and of the Tartar of the Teeth.*

1. THE cavity of the mouth, from the margins of the lips to beyond the velum pendulum of the palate, and as far as the upper part of the pharynx, is constantly moistened by several liquids which have their source in different glandular and secretory organs, whose seat, form, structure, excretory ducts and functions have much occupied anatomists and physiologists. Very numerous mucous crypts and granulated pellicles occupy the whole surface of the tongue, and especially of the infralingual cavity, of the buccal and palatine membrane or of the glandular expansion of Morgagni, of the alveolar arches, and pour into this cavity an humour somewhat less thick and mucous than that of the nostrils, which maintains on all the sides of the mouth a continual softness and lubricity, adapted to facilitate their motion, to enable the alimentary bolus to slide down, and to prevent that thirst which dryness of these parts, from whatever cause it may arise, constantly produces. This kind of mucous and lubricating humour have

have never been examined in particular, nor could it, either because it is not sufficiently abundant to be collected separately, or because it is always mixed with the salivary humour and the humour of the tonsils which incessantly flow into the mouth. For the rest, it does not appear to be in any respect different from the humour which is secreted in all the cavities in order to lubricate them, and of which we have already treated.

2. The tonsils, organs very singular in their form and their fungous structure, placed on both sides of the throat before the passage of the alimentary bole, and between two membranous columns which support the velum palati, incessantly discharge into the posterior fauces, by the numerous crypts and pores with which their whole surface is covered, a somewhat thick and glairy humour, which is frequently seen about them when they are viewed with attention, and which we feel detach themselves like small gluey masses by the rapid motion which is communicated to the air in the action of hawking. It is believed that this humour, the quantity of which must be pretty considerable from the size of the organs which furnish it, is of the same nature with that of the crypts, and that of the glands of the mouth. No particular examination however has been made of it, and we still judge of it only by the analogy of its place of structure and its uses.

3. The

3. The saliva, properly so called, separated from the blood in the parotids, the submaxillary and sublingual glands, poured into the mouth by the ducts of Stenon from the first, of Warthon from the second, and of Rivinus from the third, has been, if not analyzed with much attention, at least sufficiently examined by Vieussens, Pott, Nuck, Barchusen, Verheyen, Boerhaave, and Haller, to be better known than the preceding liquids. Haller, in his great physiological work, has collected all that physiologists had observed before him. I have added some facts to those which had been indicated by the authors abovementioned. Citizen Michel de Tennetart has described some phenomena which this humour presents in acting upon the metallic substances. Citizen Lachenaye has given a sufficiently detailed analysis of the saliva of the horse; but none of these chemists has announced more experiments, or a more conclusive series of inquiries, than M. Siebold, who published, in 1797, at Jena, a sufficiently detailed dissertation in quarto, upon the salivary system, considered in a physiological and pathological point of view. I shall borrow from these different authors, as well as from my own observations, what I am about to say concerning this humour.

4. The saliva is a slightly viscous liquid, strongly characterized by its frothy state, its insipid and partly saline taste, its want of smell, its  
sweetish

sweetish odour, and its white colour mixed with a blueish cast. Its weight is to that of water, according to Haller, as 1960 to 1875, and according to Mr. Siebold, as 1080 to 1000. The proportion of its consistence, or of the cohesion of its molecules to that of water, as 30 to 10. Mr. Siebold, in order to define this consistence in a more perspicuous manner, says that it resembles a mixture of one part of gum and forty parts of water. It is neither acid nor alkaline: it does not change the natural state of any vegetable colour. Brugnatelli asserts, that he has found it impregnated with a large quantity of oxalic acid in an emaciated venereal patient, who appeared to him to lose, by this evacuation, the nutritive and saccharine part of his aliment. Its quantity varies greatly. Nuck estimates it between 256 and 384 grammes in twenty-four hours. In excessive salivations, its discharge has been to the amount of two or three kilogrammes daily: Turner estimates its whole quantity, discharged during an entire mercurial course, at 60 kilogrammes or 120 pounds. Some authors have asserted that the saliva carried mercury along with it; but it has never been practicable to extract any from it in the experiments made in the laboratory of the Ecole de Medicine of Paris.

5. The saliva, heated or evaporated, leaves but very little residue; it swells considerably, and soon dries into small white or yellowish, saline and acrid plates. When it is evaporated  
to



to a third of its quantity, and afterwards suffered to cool and repose, it affords crystals easily distinguishable as muriate of soda, by their cubical form, their saline taste, the muriatic acid vapour which the sulphuric acid disengages from them, and the curdled precipitate which they form in the nitrate of mercury. Gently evaporated to dryness, the saliva leaves a residuum like the glutinous matter of flour, which swells and inflames upon the coals, exhaling a smell of burned horn or hair. A smell of Prussic acid is also perceived. When the saliva is subjected to distillation in a glass retort, we see a froth arise upon it, which occupies a large space; it affords all the products of the animal matters, and leaves a coal in which I have found, besides the muriate of soda, phosphates of soda and lime in considerable abundance. Prussic acid is also very perceptible amongst the products. The proportion of ammonia formed is not larger than in the distillation of the other animal matters.

6. When exposed to the air, the saliva absorbs a considerable quantity, and froths much by agitation; at the end of some hours, according to the observation of Mr. Siebold, it presents a light pellicle, exhibiting the prismatic colours, and of a fatty appearance at the surface; it soon becomes turbid, and deposits flakes; it exhales a very lively and very pure ammoniacal odour. Macbride believed that there escaped from it a large quantity of fixed  
air:

air: this he particularly concluded from the large volume and the frothy state which it assumes in vacuo: it is well known that it is ordinary air which is disengaged in this experiment. The saliva putrefies and becomes very fetid after the ammonia which has formed in it has been disengaged. This humour, however, has been considered, according to the experiments of Pringle, as eminently antiseptic, and it has been pretended that it checks the putrefaction of meat immersed in it. Indeed, a greater number of authors have on the contrary ranked it amongst the most powerful ferments, and have particularly designated it as promoting the vinous fermentation of the farinaceous substances; they have even thus explained how the savage nations of America and Africa prepare intoxicating liquors with masticated roots and seeds, which they afterwards expose to fermentation. This property deserves still to be better ascertained by accurate experiments.

7. The saliva has long been known to corrode or oxidate iron and copper pretty quickly. It was also customary, in the laboratories of pharmacy, to spit in the mortars in which the mercurial ointment was prepared, and it was known that this process accelerated the extinction or the black oxidation of the mercury. Citizen Michel du Tennetier, professor of chemistry at Metz, discovered, about twelve years ago, that when leaf-gold and leaf-silver were triturated in

in saliva, the oxidation of both these metals, which are so difficult to be burned, was effected. It appears that it is still more easy to oxide mercury by itself in this animal liquor, from a method which has been long practised by the English sailors, and which consists, according to what I have heard from able physicians of that nation, in kneading some globules of mercury in the hollow of the hand with the aid of saliva, and immediately taking the mercury thus extinguished. By rubbing mercury in small globules adhering to the fingers greased, upon the inside of the cheeks, and as in the method of Clarke, venereal symptoms are cured: all these phenomena depend upon the same cause.

8. The saliva mixes but imperfectly, and does not completely dissolve in water; it swims at its surface, and remains well separated from it. This effect has been attributed to its viscosity and sluggishness; to which we must add the little soluble nature of the animal mucilage contained in this liquor. Ebullition of the water coagulates some flakes in it, and retains the saline matters, which it separates from it. The strong acids, in small doses, thicken the saliva, as we perceive in the mouth when we hold an acid liquor in it; in larger doses they dissolve it. The fixed alkalis and the earths immediately disengage ammonia from it. Lime-water, and the solution of barites form a precipitate of phosphate of lime in it; the oxalic acid  
shows

shows the presence of lime by the precipitate which it produces, though it be very slight. The metallic solutions, especially the nitrates of lead, of mercury, and of silver, render the saliva very turbid, and produce an abundant precipitate in it: it was especially by these means that I found the phosphates that exist in this animal liquid; for these metallic precipitates afford very sensible traces of muriatic acid and phosphoric acid both at the same time.

9. From all the facts here enunciated it follows that in man, the saliva is formed of a quantity of water, which is estimated at  $\frac{2}{3}$  or  $\frac{4}{5}$  of a highly aerated animal mucilage, frothy, almost insoluble or very little soluble in water, or of a small proportion of albumen and of saline matters, which are muriate and phosphate of soda, ammonia and lime. This manner of conceiving the composition of this liquid, besides that it is the result of the experiments hitherto made upon its nature, explains also all the phenomena which the saliva presents, its semi-coagulation by fire, by the acids, and by alcohol; its difficult solution in water, the light flakes which it affords in many cases, its sluggish viscosity, its frothy property, and its precipitation by a multitude of bodies. The saliva must be considered as a condensed solution of this viscid mucilage, which very readily detains the air into which it is immersed, to carry it into the alimentary bile, and into the stomach. The salts which it contains

tains may vary in their proportions, and actually do vary, according to a multitude of circumstances.

10. It frequently happens that there are formed in the strainers of the saliva, and deposited in the excretory ducts of the salivary glands, some kinds of concretions or calculi, which have been improperly called stones. They have been particularly observed in the Warthonian duct much more frequently than in the Stenonian, or that of Rivinus. Haller, after having quoted a multitude of examples from authors, inquires what may be the cause that favours this formation in the first class of these ducts rather than in the two others. We are not sufficiently acquainted with the structure of the different salivary glands to be able to pronounce upon the cause of this singular prerogative of the Warthonian duct. Scherer, in a dissertation intitled *De calculo in ductu salivali*, has described with great care the maladies which this species of concretion produces, and all the circumstances which accompany it. Hippocrates was already acquainted with the stone under the tongue. The tumor called *ranula*, and *anginas*, have been known to be the consequences of this kind of concretion. Many facts have also proved that it is speedily formed. I have examined one of these salivary calculi given me by Citizen Sabbatier, and I found it to be composed of phosphate of lime and of a kind of animal mucilage. Its source  
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is therefore manifestly in the saliva, which, like all the white and more or less viscid humours, contains phosphate of lime, the proportion of which is sometimes augmented by causes that are hitherto unknown or undetermined. It appears that this augmentation depends, in several circumstances, upon a general cause, and that it takes place in all the humours at the same time, undoubtedly because the ducts which naturally evacuated its superabundance are then too much constricted. In such case, similar concretions are formed in many places, and some are deposited even in the substance of the membranes.

11. Those very frequent incrustations which surround the base of the teeth, and are known by the name of tartar, which loosen and repel them, destroy the gums, and sometimes become so considerable that they separate and displace the teeth themselves in some individuals who take no care of their mouths, are also of the same nature. The saliva, and the other juices of the mouth which incessantly bathe these bones, and remain between the margins of the gums and the teeth, gradually deposit upon them, by a real crystallization, particles of this earthy salt; and it is not to the residue of the aliments, as is commonly believed, that this pretended *tartar of the teeth* is to be attributed. When we examine with a good magnifying glass the tartariform concretion which encircles these bones towards their

base, and which sometimes extends as far as their alveolae to the sides of which it attaches itself, we find it composed of small grains united together and brilliant in some points. We perceive in it, by the microscope, a great number of pores or small polyhedral cavities which resemble the cells of polypuses in their form and arrangement. Magellan, the philosopher who undoubtedly saw microscopic animalcul in it, thought that this concretion was a sort of nidus of *polypuses* formed by these animals. But it is more natural to believe, that this crystalline deposition of the humours of the fauces, similar to the concretions so generally diffused and so common in the animal economy, receives at its surface and in its pores some particles of alimentary residue, charged, like every soft, humid, and warm organic matter, with microscopic animalcul. The nature of this deposition upon the teeth is really phosphate of lime, mixed with a portion of mucous and glairy substance: accordingly, the acids dissolve it, as has long been known, by the employment of these substances adapted for cleaning the teeth, upon which indeed the acids act in a dangerous manner if care be not taken to confine their operation merely to the layer of tartar which surrounds and covers them.

## ARTICLE XVII.

*Of the Cerumen of the Ears.*

1. THE cerumen of the ears, so called on account of the consistence of soft wax which it commonly has, attracted the attention of the ancient physicians much more than of those of the present age. The ancient schools, as Bourdeu has observed, taught that the gall-bladder was purged of this humour of the ears. Hippocrates assiduously occupied himself with the consideration of it in diseases, and compared its production with the flow of the bile: the moderns have intirely neglected this kind of observations; and at the present day the analogy, which subsists between this humour and that secreted by the liver, seems forgotten. The cerumen, however, possesses properties so remarkable, so different from those of most of the other animal liquids, that I have thought I ought to assign to it a particular article. What does not appear striking to every one at present may appear so hereafter. This assertion is particularly applicable to the matter which forms the subject of the present article, and of which but very little has been said by any author, even amongst those who have particularly occupied themselves with the organ of hearing,



Cassebohm, Valsalva, Duverney, Schroeder, Le Cat, &c. Haller, who according to the order which he had adopted, exhibits by his vast erudition all that the anatomists and physiologists had discovered before him, has scarcely devoted five or six lines to the examination of the distinctive properties of the cerumenous humour.

2. This humour is prepared in a particular glandular apparatus discovered by Stenon, seen by Drelincourt, well described by Valsalva, Duverney, and Haller. It consists of small round and oval glands, of a brownish yellow colour, of a very firm consistence, disseminated under the skin, and placed, either in the excavations of the osseous auditory passage, or in the cartilagineous portion of this passage, especially towards its anterior part. Each of these small glands has a very short cylindrical duct, which perforates the epidermis, and opens into the auditory passage by an orifice visible to the naked eye. There runs out from it a small drop of a yellow humour, at first a little viscid like an oil, which quickly thickens in the warm cavity of the ear by the contact of the air, and is converted into a kind of unguentaceous matter, of a deep yellow or orange colour, or even reddish, of a very bitter taste, which inflames when it is heated, as Boerhaave had especially indicated. Pechlin has compared the cerumen to castoreum. It had especially been remarked that this humour might, by remaining  
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for a long time in the auditory passage, thickened in such a manner as to form a solid cylinder, capable of obstructing the passage like a real stopper, and prevent sounds from arriving within it; that this thickening, which some authors have observed as far as concrete and plaster-like state, was a frequent cause of deafness, and that it was cured by injecting soap-water.

3. These facts comprehend, even in the most learned and extensive works, the whole history of the cerumen of the ears. Bordeu, who in many parts of the art, wished to revive the notions of the ancient physicians, and especially those of the Coan school, contented himself with prognosticating, after having noticed the attention which this school paid to the cerumen, that some practitioner might meet with a particular case adapted to explain the pretension of one of the ancients with respect to this subject. Nearly thirty years have elapsed during which this suggestion of an enlightened man has called in vain for observations. Whilst I indulge the hope that physicians may bestow upon the subject the attention which it deserves, I shall exhibit some ideas respecting the chemical properties of this humour, which is difficult to be procured in the abundance requisite for subjecting it to extensive researches. I must say, that of all the physicians whom I have acquainted with the importance which I attach to the examination of this humour, my colleague

league Hallé was the person who was most struck with it, and that he succeeded, by his enlightened zeal for the progress of our art, in furnishing Citizen Vauquelin and myself with a sufficient quantity of cerumen to enable us to begin an exact analysis of it.

4. The cerumen collected during several successive months by a healthy individual, with the aid of an ivory ear-spoon, and kept in a piece of paper, impregnates the texture of the paper like a fat oil rendering it transparent, and preventing water from penetrating it. It is easy to be united and kneaded into a single mass; I have formed an almost solid ball of it, which was of an orange-yellow colour, nearly without smell, of the consistence of soft wax, and of a bitter, disagreeable taste. When placed upon an ignited coal, the cerumen instantaneously melts; it quickly swells and exhales a thick fume, the smell of which is ammoniacal, and of a sensibly aromatic fetidity; it does not differ much from that of burned horn or hair; it emits very little flame at the end of this operation. It leaves a coal, which has lost the pretty considerable volume which this matter had at first assumed, and which is too little abundant to be analysed: this coal is difficult to be incinerated. We had too small a quantity of cerumen to be able to distil it, especially after to the little light which this experiment promises.

5. The

5. The cerumen triturated with water, in a mortar, dilutes pretty well and dissolves in part. It affords a kind of emulsive liquor, of a yellowish white colour, in which we see small drops of oil collect at the surface. This is manifestly the effect of a mucilage holding for some time an oil in suspension. The matter thus diluted is susceptible of the putrid decomposition, though the intire cerumen keeps for whole years without any sign of putrefaction; it is, next to the solid or osseous parts, the least alterable of the animal matters. Alcohol takes up but very little from it, and is only slightly coloured, even when it is boiled for some time upon the cerumen: when this coloured alcohol is filtrated and left to cool, a portion of the matter which it had dissolved is separated so that the liquid becomes turbid and slightly milky. According to the comparison of this action of water and of alcohol, the cerumen appeared to us to be an intimate mixture of an animal mucous substance with an oily or fatty matter, rendered concrete by the absorption of atmospheric oxygen. This last matter renders it similar to the bile, to which the ancients had already found it to be analogous.

6. Thus much I, for my own part, was able to ascertain respecting the cerumen, from the small quantity which I had collected from myself. Since these first experiments, Citizen Vauquelin, who had undertaken to examine the cerumen with which our colleague, Citizen Hallé,

Hallé, had furnished us, and who having a much larger quantity of it, was able to subject it to a more regular series of experiments, gave me reports of them, of which I shall here exhibit a sketch, as it is adapted to extend the notions which I have already given, and to give them still greater precision.

The mass which he had to examine formed a ball, some centimetres in diameter, and nearly six grammes in weight. This matter is pitchy, of a bitter taste, of a deep orange colour: put upon a piece of paper and slightly heated, it melts, penetrates, and spots this texture, rendering it transparent, as oil does. It has a very particular, slightly aromatic, and somewhat acrid smell, especially when it is heated and rubbed between the hands.

7. Placed upon an ignited coal, the cerumen softens, and exhales a white fume, which has the smell of burned fat; it soon melts, swells, becomes coloured, and emits an ammoniacal and empyreumatic smell. After this action of the fire, there remains a voluminous and rather light coal. Diluted with water, the cerumen forms a kind of emulsion of a yellowish white colour, which quickly putrefies and becomes very fetid. Though water does not dissolve it, it however takes something from it; for, in putrefying, it deposits whitish and mucilaginous flakes. Treated with alcohol, with the assistance of heat, it communicates to it a saffron-yellow colour, and by cooling, some white flakes are  
1 deposited.

deposited. Sulphuric ether also dissolves part of the cerumen ; and though it deposits nothing by cooling, it acquires a slight colour by remaining some instants in contact with it, either in the heat or in the cold.

8. Two grammes of cerumen treated with hot alcohol lost 1,25 grammes, and afterwards weighed only 0,75 of a gramme. The portion not dissolved, when dried in the air, was transparent, brittle, less coloured, less fusible by the fire, and exhaled, while it burned more ammonia than oily vapour ; the coloured alcohol afforded by evaporation a residuum of a pretty dark colour, considerably bitter, of a consistence and smell resembling those of turpentine, fusible without swelling, volatilizing into a white vapour of a fatty smell, and without leaving any perceptible coal : it had all the characters of a fixed oil.

Two grammes of the same cerumen, treated with sulphuric ether, with the application of a little heat, lost 1,25 grammes, and weighed now only 0,95. The liquor was less coloured than that of the alcohol ; evaporated by a mild fire, it left a matter of a pale-yellow colour, of a tenacious consistence like turpentine, of a smell analogous to that of this resin, and less bitter than that which had been obtained by the alcohol. The 0,95 grammes not dissolved by the ether, resembled the residuum left by the alcohol, and exhaled much ammonia upon ignited coals. There is, therefore, a striking resemblance

blance between the action of alcohol and that of ether upon the cerumen: both take from it a matter of an oily nature, more soluble in the first than in the second of these liquids, and leave an insoluble animal substance.

9. The kind of fatty oil separated from the cerumen by the alcoholic liquids, is fusible, and diffuses upon the coals a pungent adipose smell; a little coloured, and it is susceptible of dissolving in the fixed and volatile oils, but with difficulty in cold alcohol; though very completely if we employ a large quantity of this liquid. The leys of fixed alkalies unite with it by mere trituration, and form with it a kind of soap, which does not, indeed, assume either the taste or the consistence of common soap.

As to the matter insoluble both in alcohol and in ether, since it becomes dry and brittle in the air, since it softens and even partially dissolves in water, which afterwards putrefies; since it is capable of exhaling empyreumatic ammoniacal fumes whilst it swells upon the coals, and of dissolving, though imperfectly in the alkalies, these characters manifestly belong to albumen; and what confirms this notion is, that when it is burned in a crucible of platina, it leaves a light coal of an acrid and alkaline taste, manifestly containing soda and phosphate of lime.

10. Besides these two substances, the bases of the cerumen of the ears, it manifestly contains a distinct colouring matter, though it has not  
yet

yet been obtained separate, on account of the too small quantity which we have hitherto had of this animal product. It appears that this colouring matter is the cause of its bitterness, and that it is the principle of the cerumen which varies the most, since in fact the most striking differences which are remarked in it relate to its colouration and its bitterness.

Citizen Vauquelin has given the following result of this mass. The cerumen of the ears is a compound of three substances: 1st. a fatty oil, more analogous to that which is contained in the bile, than to any other adipose animal matter; 2d. an albuminous animal mucilage; 3d. a colouring matter which seems to resemble that which forms part of the bile, by its bitterness and its adhesion with the fatty matter.

11. The uses ascribed to the cerumen are, to soften and lubricate the sides of the meatus auditorius, to deter insects from entering into this passage, by its bitterness, to soften and even deaden the sonorous vibrations of the air, and thus to moderate the force of sound. There is reason to believe, from the oily nature of the cerumen, and its bitterness, that it ought to be ranked in the class of excretions, and that it evacuates a particular acrid matter. If, as the ancients remarked, its quantity increases in some circumstances of diseases, and if its proportion answers to that of some other evacuations, the observations which Bordeu called upon the physicians to make, may some day afford



afford more light respecting the uses of this humour. Haller does not forget to remark, according to Derham, that birds have no cerumen, and that it is found only in those animals whose meatus auditorius is more or less elongated. In fact, it is abundant in some of the mammalia; and it would be of great utility to the art to examine it with care in these animals, in order to ascertain its properties and the relations or differences which subsist between it and that of man.

### ARTICLE XVIII.

*Of the Tracheal and Bronchial Humour; of the Pulmonary Gas, and of the calculous Concretions of the Lungs.*

1. BY referring to this article, all the animal matters which belong to the chest in particular, and which are situated within the cavity of the thorax, we find a much greater number of these matters than I have inserted in this title. In fact, we must rank in this class the tracheal humours, the humour of the bronchial glands, the arterial and the venous blood, the air inspired, the air expired, or the pulmonary gas, the pulmonary transpiration, the humour of the pericardium, that of the pleura, the concretions of the lungs, the parenchymatous

tous texture of this viscus, and the texture of the heart. But amongst these twelve substances, there are many which are already known, and which have already been treated of in the articles concerning the matters generally diffused throughout the whole body. In fact, I have elsewhere shown the difference between the pulmonary, arterial and venous blood, and the blood of the other regions. The air inspired is that of the atmosphere, which has been examined in detail in the second section; the pulmonary transpiration has been compared, in one of the preceding articles, with the cutaneous perspiration of the whole body; the humour of the pericardium and that of the pleura present no difference from that of the other internal membranous surface; the parenchymatous texture of the lungs, which has been confounded with the cellular texture, has not yet been particularly examined; that of the heart is only muscular fibre, more dense than that of most of the muscles. There are therefore to be examined with more detail, only the tracheal and the bronchial humours, the pulmonary gas, or the air evacuated by expiration, and the calculous concretions. I have not even comprehended, in this general enumeration, the humour of the thymus; because, excepting that it has been compared with milk on account of its whiteness, its nature is absolutely unknown. Not the slightest experiment has been made upon its composition and its properties, though  
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this object is very interesting, and deserves all the attention of physiologists.

2. The larynx and the trachea are continually lubricated and moistened by a humour which extends throughout the whole continuity of the bronchial, and which covers, lubricates, and softens their internal membrane. This humour is a little viscus and gluey; it is transparent, and of such a consistence, that it cannot flow; for, had it this character, it would incessantly irritate this very delicately sensible passage, and excite a perpetual cough. This humour of the trachea appears to be of the same nature as that which moistens and lubricates all the other cavities or hollow membranes. It is, however, probable, that this liquid has not the same saline character as the saliva, the mucous humour of the mouth, &c. It is known that the tracheal humour has neither taste nor smell. Hitherto it has not been possible to make any particular analysis of it, because it is not easy to procure a sufficient quantity of it for this analysis. Anatomists have attributed the origin and referred the source of this liquid to mucous glands or crypts, situated under the internal membrane of these air ducts; sometimes it is discharged in the form of sputa. It cannot be doubted that, being incessantly in contact with the air which penetrates the bronchial vesicles, this humour thickens, either by the evaporation which it undergoes, or by the action which the atmospherical oxygen gas exercises

cises upon it. Some physiologists have erroneously attributed to it the blackish blue colour, of certain flaky matters which are coughed up, and which proceed from another source, of which I shall speak in the following number.

3. The tracheal humour is considered as adapted to prevent the dryness of the internal surface of the larynx, of the trachea, and of the bronchia, a dryness which would easily be occasioned by the contact of the air, that continually passes through these cavities. It is also believed, that it defends the membrane of these very sensible passages against the action of different acrid substances and irritating powders, so often disseminated in the air which incessantly traverses them; finally, the use is attributed to it of rendering the voice soft, and preventing the roughness and hardness which the sounds issuing from the lungs would have, if these tubes were dry and destitute of this lubricating mucilage. The air which descends very dry and very cold into the lungs, takes away much of the evaporable or aqueous part of this tracheal humour, and gives it a remarkable character of glutinosity and adhesion to the sides of the trachea; in this case this thickened matter, which can no longer be easily absorbed, is discharged by the cough which its weight and its irritation excite: such is the cause and the nature of catarrhs. The glairy laminæ, or the more or less concrete flakes, are separated only by a violent effort of  
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the air which impels them, and then the cough is convulsive or painful; or else they are raised or slowly detached from above the tracheal membrane, by this liquid humour which exudes beneath them, in which case they are coughed up with more facility and less pain. It is in this manner that confinement to the bed, by retaining the perspirable matter in its vessels, and causing that of the lungs to be more abundant, operates.

4. I distinguish by the name of *bronchial humour*, a kind of matter separated by the glands of the same name, which is poured into the bronchia by particular small excretory ducts. It is very different from the tracheal humour; it is not viscid, ropy, nor extensible like that matter. It is discharged in the morning in the form of small, irregular, and most frequently roundish lumps, of a consistence resembling a thick jelly, of a blackish or bluish colour, insoluble in water, at the surface of which they swim; its quantity varies in different individuals. Though it has not yet been particularly examined, its sensible characters are sufficient to distinguish it as a peculiar matter. The glands which furnish it, and which have not yet perhaps sufficiently fixed the attention of anatomists or physicians, have themselves a structure very distinct from all the other glandular organs. They have been erroneously confounded with the system of lymphatic glands. Their form, their size, their texture, their

their colour, even their consistence, and their diseases, every circumstance claims the attention of scientific men to this organ hitherto too little known. We might be induced to suppose, when we observe their blueish or blackish grey colour, their consistence, and that of the humour which they furnish, that they form a kind of reservoir for the carbonous matter of the blood. Many observations, followed up with zeal and sagacity, are required in order to determine the uses and the functions of this particular glandular system.

5. By calling the elastic fluid which is discharged from the lungs by expiration *pulmonary gas*, my intention is to announce that the atmospheric air, after having remained for some time in the lungs, is discharged from them in a state of alteration which depends upon the nature of this organ itself, and which I have already indicated in the history of the blood. This fluid is nearly the same in quantity as it entered, since the carbon and the hydrogen, as well as the water ready formed, which are added to it, correspond very nearly with the proportion of oxygen gas which it yields to the blood. It contains no more than a few hundredths of this oxygen gas; and if it has been respired two or three times in succession, which cannot be done without much difficulty, it contains none at all: accordingly, it extinguishes inflamed bodies, and stupefies animals. We find in it the same proportion of azotic gas

as before. Water is one of the materials that are added in the greatest abundance to this expired gas, since nearly half a gramme of it is expired every minute, or 720 grammes in 24 hours. We also find in it gaseous carbonic acid, proved by the precipitate formed by the expired air when received into solutions of lime, of strontian and of barites; it is also charged with more caloric than it contained when it entered the lungs: and this is the reason why it deposits water in the form of fumes when it passes into a cold atmosphere. Perhaps it may also contain a certain portion of carbonated hydrogen; and we may attribute to this substance, which has not been rendered sensible in it by chemical experiments, the dangerous and deadly effects which it produces, and which are different from the asphyxia; perhaps some animal miasma, some contagious virus may escape at the same time with the air expired. As it has not yet been exhibited by experiment, it is only by conjecture that we may suspect its influence in the production of diseases, and the septicity which it introduces into the humours of those who respire it. Chemistry ought to occupy itself without intermission in confirming or overturning these ideas, and rank them amongst those physical truths, the proofs of which medicine must either confirm, or else arrange them in the class of hypotheses; in fact, these are adopted in  
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the theory of this important art only for want of exact experiments and facts.

6. One of the matters peculiar to the organs contained in the thorax, and which is only the product of a morbid alteration, but more frequent than has hitherto been believed or asserted, is a concretion formed in the lungs, which has been called *pulmonary stones*, or *calculi*: these are small, hard, unequal and rough bodies, of an irregularly spherical form, resembling small pebbles, of a grey or reddish colour, which becomes white when they are dried in the air, and which are discharged by coughing, sometimes even whilst the person is in perfect health, but most frequently in the course of some attacks of asthma, or of the terrible phthisis pulmonalis. Attentive physicians and exact observers frequently meet with them in their practice. Through their care I have had a sufficient quantity of them to be able to examine them: I have found them to be of the same nature with the pineal, lacrymal, and salivary concretions: they are composed of phosphate of lime, and of a small quantity of gelatinous matter. It is not known whether they proceed from the texture of the lungs or bronchia itself, when the patients discharge them; but dissections prove that they are formed in the areolæ even of the parenchyma of the lungs, since in cutting the lungs a great quantity of them are sometimes found, which grate under the scalpel. Here, as in many



cases already mentioned, this phosphate of lime deposited by its superabundance proceeds from the white humours, when the concretion is small and insulated: but it may proceed also from the blood, especially, when, being numerous and disseminated in the interior of the organs of respiration, these concretions appear to occupy at the same time the whole texture of the lungs.

## ARTICLE XIX.

*Of Milk and its different, economical, chemical, alimentary, and medicinal Properties.*

### SECTION I.

*Natural History, or Formation of Milk.*

1. MILK, a liquid so well known, so useful, so generally employed as food and condiment, is one of the substances which have been most examined by chemists, as it is one upon which the processes of the arts have been extremely varied. Its history must be one of the most detailed, as it is one of the most important matters with which chemistry can be occupied: accordingly, we shall divide this article into eight paragraphs, in order to dispose in a methodical order, adapted for facilitating its study, the facts which will lead us to under-

understand its properties. The first paragraph will contain an account of its formation; the second, that of its chemical properties; the third, the chemical examination of the entire milk, such as nature presents it when it issues out of its reservoirs; in the fourth I shall treat of the whey; in the fifth of the caseous part, or cheese; in the sixth of the butter or its oily matter; the seventh will be assigned to the examination of the principal differences which this liquid presents in the species of animals which furnish it; finally, the eighth will contain the enumeration of the various uses for which different kinds of milk are employed in rude or civilized society. As milk is one of the liquids with which Nature has supplied the first wants of men, it is not to be wondered at that an immense number of observations have been collected respecting its properties, and that its history, when we consider it successively as naturalists, as physicians, as chemists, or as economists, presents very extensive details.

2. This liquid is formed in a particular organ which occupies the anterior part of the chest, in women, and a large part of the abdomen in the female animals. As there are only a small number of species of animals in which this formation takes place, and as these animals are distinguished from all others by the two well marked characters of bringing forth their young living, and of being provided with *mammæ*, they have been called *mammalia*: these are,  
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under other anatomical relations, viviparous quadrupeds and cetacea. The very beautiful form, the distinct protuberance, the hemispherical and prominent surface, the delicate skin which the breasts of women exhibit, and which constitute one of the charms of beauty, the amenity and contour of which artists represent with such graces, are attributes peculiar to the human species. We do not find them in the females of any other animals: the number of two is also given to but very few species of these. In most, the number of mammæ amounts to between four and ten. The female elephant, the mare, the gazelle, and in general those animals that have only one or two young have also only one or two mammæ, but shaped very differently from those of woman. The nipple is single in each mammæ in woman; it is quadruple in the cow.

3. In works of physiology and medicine, examples are frequently quoted of milk ready formed, swelling the mammæ of some male children and animals, and even of some adults: the presence of this liquid in young girls before the age of puberty is still more frequently spoken of. Hence it is concluded that there is no necessary dependance between this formation of milk and the act of generation; but these rare facts, contrary to the accustomed order of nature, do not prove the opinion which is attempted to be established upon this point: for no accurate experiment has proved that this was real milk:

milk : and as for its having a sweet or insipid taste, an humour formed in some circumstances and by some causes independent of pregnancy, is not real milk. This rare phenomenon has never been described except in man, and it has not been observed in the animals whose passions and manner of living are not, like ours, contrary to nature, nor force her to deviate from her ordinary course.

4. Under the skin of the mammæ are masses of solid and granulated fat, which it covers ; and in a cellular texture with large meshes is inclosed a conglomerate glandular apparatus, covered with a hard and white integument that occupies the middle of this prominent organ. This apparatus is formed of parcels separated by membranous cells, and these parcels are themselves formed of hard, solid, entire grains without cavities, composed of implicated vessels. This mammary gland exists in males and in infants, but much smaller, and not surrounded with fat as in females : fifteen or twenty excretory ducts, visible, elongated, hard, of a diameter sufficiently considerable during the period of lactation, are collected below the areola of the breast, and proceed, without confounding themselves or anastomosing with each other into the nipples, where they open externally ; they are inflected into the rugosities of the papilla or nipple, and elongated or distended when the nipple itself is elongated by the  
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kind of erection which friction or suction produces in it. A multitude of other thin and long ducts are observed, which open into the adipose texture, which do not belong to the glands, properly so called, and which Haller imagined to pour a fatty humour into the milk.

5. When the uterus has conceived, the mammæ gradually grow larger, their glandular texture tumefies, the orgasm pervades it, the disposition to form milk gradually establishes itself, which is announced by a limpid or turbid serosity discharged by the papilla. After the birth of the infant, the womb having contracted itself again three or four days after delivery, the milk begins to be really formed; the mammæ become distended, swelled, and painful, and the milk discharges itself spontaneously. The suction of the infant greatly accelerates its discharge, and augments its production. There first runs out a very liquid slightly and opaque liquid, which is the colostrum; soon afterwards, this liquid becomes daily thicker, more perfect, white, odorous, savoury, and susceptible of affording a more and more substantial nourishment to the suckling. It continues to flow for whole years, when the suction and the irritation are not interrupted, and the quantity which is formed is sometimes so abundant that a nurse can suckle several infants at the same time.

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6. The formation and, as it is called, the rising of the milk has great relation with the functions of the uterus. It seems at first that a really milky liquid is formed in this viscus; and the lochia, which have in part the same character, flow till the period when the milk is abundantly secreted in the breasts. Physicians believe that this liquid actually passes from the uterus into the breasts, and a great number of facts proves this sympathy between these two organs. They both assume their peculiar activity at the same period: the breasts become prominent as soon as the menstrual discharge appears, or the genital parts develop themselves; the milk begins to be separated when the menstrual discharge disappears in consequence of pregnancy; its suppression causes the mammary glands to become humid: these glands collapse when the menstrual discharge ceases; and these two organs, the womb and the breast, become inactive, and are excited into activity at the same periods. Physicians even avail themselves of this action when, in order to diminish the too great abundance of the menstrual evacuation, they apply a cupping glass to the breast. Discharges by one or the other way succeed, and correspond with each other. This relation is also proved by the sensation which the titillation of the nipples excites in the genital parts; accordingly the ancients admitted the concurrence of the uterus in the formation of milk.

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7. Some anatomists admit the blood only as the source of the milk ; they believe the mammary arteries to be its sole origin. The smallness of these sanguineous ducts has induced others to think that the arteries do not furnish the only matter of the milk. Haller admitted in it the admixture or the addition of fat by the ducts of which I have spoken. It is pretty generally believed that the chyle contributes more abundantly than the blood to the formation of the milk, because its quantity is always proportionate to that of the nourishment ; because the chyliferous vessels exhibit to the anatomist a liquid analogous to milk ; because milk has frequently the smell and several of the characters of the aliments ; and lastly, because nurses feel the milk flow into their breasts at the moment when the chyle ascends into its vessels. For these reasons physicians have believed that these two liquids are similar to each other, and have described the properties and the morbid affections of the different elements of the chyle like those of the milk : but this analogy, when carried too far, may be erroneous, and experience has not yet proved it in a direct manner. I am much more inclined to believe that the intire lymph, the quantity of which is augmented, and its motion accelerated by the chyle at the moment when it ascends from the intestines into its ducts, contributes to the production of the milk, and that while the blood furnishes the albumino-caseous part, the fat affords

fords the butyraceous, and the lymph the serous.

8. When the milk is well formed, and distends its reservoirs, frequently the lactiferous or galactophorous tubes, being opened and dilated, discharge it spontaneously: a kind of orgasm pervades these tubes, erects them, dilates them, afterwards contracts them, and gives them that motion, that action which frequently causes the milk to issue out in more or less rapid jets. That suction, or the art or mode of which nature has given to the infant from the necessity of nourishing himself with it, singularly favours its discharge. The vacuum formed round the nipple, with the aid of a sucking instrument, or by means of the neck of a heated bottle applied to it, and the pressure of the air which applies itself with advantage to the hemisphere of the *mammæ*, solicits this discharge with such energy, that we see it spout out in white streams, of which frequently six or eight are very evidently perceived in the females of animals; the action of pressing the udder from above downwards as far as the extremity of the teat, in milking, or the art of milking, causes the milk to flow with facility and celerity. The animals that have had their young taken from them readily submit to this extraction, which is attended with a pleasurable sensation to them. Nature has connected with this excretion a pleasurable sensation which doubles, that of being a mother,



ther, and which attaches, by the gentle bond of gratitude and tenderness, the infant who acknowledges no other mother than her by whom he is nourished.

9. The influence which the aliments have upon the formation of the milk, likewise merits all the attention of the physician. It is known that well-fed animals afford milk of good quality in abundance. Nurses distinguish foods by the property which they possess of increasing or diminishing the proportion of this liquid. The acrid smell of garlic, of the alliaceous and of the cruciferous vegetables, passes into the milk; the perfume of flowers, the aromatic odour of saffron and of thyme, the sugar of the roots and fruits, the nectar of the petals, give it an agreeable aromatic smell and a pleasant taste. The red juice of the opuntia, the reddish juice of madder, the blue of indigo, vary the colour of this nutritive liquid with the animals into whose food these colouring matters have been introduced; the bitterness of wormwood, the acrimony of the milk-thistle, the astringent of the astringent plants, the purgative property of the *Gratiola*, are recognized in the milk; different medicinal properties are given to it, according to the different kinds of nourishment which are presented to animals. The milk of a nurse who has taken a purgative, produces gripes and evacuations in her suckling. Wine, beer, the different vinous liquors, give it a distinguishable property;

property; even poisons, and several diseases, are transmitted in this way; and the milk participates of whatever has been introduced into the stomach of the woman who affords it.

10. Even the passions with which a nurse is agitated, modify both the abundance and the properties of the milk that is secreted in her breasts; anger has been known to derange the system of the infant, and to give it convulsive motions. Chagrin, ill humour, bad news, fear, depression of the spirits, vitiate the sources of the milk, and sometimes produce a sudden collapse of the breasts. Bad treatment to nurses, manifestly alters their milk: accordingly great care is taken of the female animals destined to furnish milk for the table, not only in the cleanliness and nature of their food, but also by kindness, caresses and attentions of every kind. Several physicians have even carried this influence of the passions upon the milk so far, that they have pretended the milk itself influenced the character and the passions of the young individuals that are nourished by it: thus it has been pretended that infants who have been suckled by choleric and passionate, mild and benevolent, lively and salacious, or stupid and phlegmatic women, acquire the same moral dispositions. But there is reason to believe that this opinion is carried too far, that it is rather from the example of the effects of these different passions that the infants gradually model themselves, and that they are only imitators

imitators of their motions instead of being physically changed in their sensorium.

## SECTION II.

### *Of the Physical Properties of Milk.*

11. THE quantity of the milk is varied in woman and in the animals by a multitude of circumstances. Abundance of drink in general, induces an abundance of the mammary liquid; soft, highly nourishing and easily digestible aliments produce the same effect. The farinaceous aliments boiled in water, when the stomach digests them well, increase its quantity, and nurses are well acquainted with this kind of influence. It is difficult to fix the limits, or indicate the average terms of this production: it appears however in general that the milk most frequently constitutes a third or a very little more of the weight of the aliments. There have been nurses however, who, besides the milk which they afforded in abundance to their infants, yielded still spontaneously from one to nearly two kilogrammes of this liquid in the day; in the female animals with which this quantity is much more considerable, it is sufficiently known to vary according to the seasons, the places which they inhabit, the pasturages in which they are placed, the nature  
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of the fodder which is given them in their stalls, their age, and the time more or less remote from the period when they have brought forth young.

12. The specific gravity of milk is in general more considerable than that of water; Haller says that it is to the latter as 277 to 261, or 1043, 1000. It varies, according to him, and the different authors whose observations he has collected in the following proportions, 1026, 1029, 1035, 1000.

Citizen Briffon, in his treatise upon the specific gravity of bodies, gives the following table of that of the different milks, water being supposed 10,000.

Womans' milk	-	-	10,203
Cows' milk	-	-	10,324
Goats' milk	-	-	10,341
Mares' milk	-	-	10,346
Asses' milk	-	-	10,355
Ewes' milk	-	-	10,409

13. Milk is in general of an opaque white colour, which however inclines towards yellow in woman, towards blue in the cow, and varies in the same female according to the proportion of its principles, and consequently, according to a multitude of circumstances. However its opacity and its whiteness are constant, on which account it has been compared to an emulsion, and the latter has been called *milk* of almonds.

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Its consistence is that of an oily and aqueous liquid at the same time; when it is very strong and very good, it is a little thick, a drop remains upon the nail without running down, and extends itself upon it slowly: it is in this manner that physicians judge of the milk of nurses; a certain degree of fluidity is nevertheless preferable to a too strong consistence.

14. The taste of milk is bland, agreeable and in general almost saccharine; it has however many modifications in the different species of animals; it has something unctuous and fatty which distinguishes it, which manifestly depends upon its oily nature. Milk has a particular smell, which is pretty generally agreeable; this is one of the properties in which it is most susceptible of variation, according to the nourishment. That which is peculiar to it is however inherent in its intimate nature, and independent of the perfume or the bad smell proceeding from the aliments; it subsists only as long as it is warm; it is most perceptible at the moment when it has been discharged from the mammæ; it is scarcely to be perceived at all when it has entirely cooled; it is renewed by exposure to heat; it is dissipated by ebullition. It is very perceptible and recognizable in clean dairies, at the moment when the warm new milk is deposited in them. The milks of different animals have a particular and well-marked character in their odour.

15. According

15. According to the observations of Citizens Deyeux and Parmentier, the milk furnished by a cow at different periods, in the space of twenty-four hours, presents great differences, especially if the milkings are multiplied at irregular distances of time. The changes of the atmosphere, for the animals fed by pasture, are the principal causes of these differences. The most singular remark which they have made relates to the diversity of the milk of a single milking, according to the manner in which this milking is divided, and the udder evacuated at different times. The product of one milking performed with care and received successively into four vessels, affords really four species of milk: the first is the most ferous: the second product is less so; the third still less, and the fourth contains a very large quantity of cream. The dairy women have long been acquainted with this phenomenon, and they avail themselves of it, by keeping apart the last product of the milking, in order to sell it, under the name of cream, to those who prefer the sweet, uncluous, thick and fat milk which goes by this name.

16. The times at which the milk is examined present variations according to the different lengths of time that have elapsed since parturition and the first formation of the milk. The most striking of these differences observed in the milk is that which characterizes it in what is called the *colostrum*, which is first formed immediately after parturition. The colostrum

is a fluid of a deep yellow colour, thick, viscid and ropy, frequently carrying with it streaks of blood, affording much yellow cream; and this a fourth more than the real cream of a deep yellow very solid butter, with a liquid less white and opaque than the ordinary milk, not coagulable, like the latter, by means of rennet, but viscid and ropy, little saccharine. The colostrum changes much; from the second day it loses somewhat of its yellow colour and of the abundance of its cream. In four days, it passes into the state of ordinary milk, and it is not till this period that the milk-women begin to vend it in our towns. Reckoning from this fifth day, the milk of the cow becomes constantly more and more perfect, acquires a better consistence till the third month when it is the most perfect.

### SECTION III.

#### *Chemical Examination of the entire Milk.*

17. I HAVE already observed that the milk has been the object of much labour and research. Boyle has made it one of the subjects of his experiments. Boerhaave first treated in a sufficiently detailed manner. Hoffman also made it the subject of many experiments. Macquer has described with much clearness and precision the processes of its analysis, and he was acquainted

quainted with its principal properties. Spelman occupied himself with its fermentifcible property ; Rouelle the younger with the mucofo-faccharine matter and the falts which it contains. Scheele difcovered the fachlactic acid, and showed that the milk afforded in fome cafes acetous acid, and that the species of acid into which it isfpontaneously converted has particular and characteristic properties. I have given, in 1790, feveral new obfervations on the different materials of milk. Finally, Citizen Deyeux and Parmentier have made a great number of refearches upon the milk of the cow, taken under many different circumftances, upon the economical properties of this animal liquor and of its products, and upon the changes or modifications of which it is fufceptible. Their very extenfive enquiry concerning all thefe objects constitutes at prefent an entire work, which presents the moft complete hiftory of this animal liquor. I have here mentioned only fome outlines of this chemical notice and fome of the principal authors of its analyfis. We might alfo add the numerous facts defcribed by Verheyen, Barchufen, Verduc, Doorfchodt, Egeling, Young, Gouraigne, Acoramboin, Geymuller, Cartheufer and Gmelin, who have either in phyfiological works or in monographic treatifes, given more or lefs valuable details concerning the milk of different animals. Haller has laborioufly collected from thefe numerous writers the facts which he has



employed for his history of milk; and as the mode of proceeding of these authors was not uniform, those multiplied quotations are more capable of embarrassing than enlightening the reader.

18. Milk exposed to a moderate fire dilates and swells considerably: this property is known in the domestic uses of milk; it has been observed that it boils at the 199th. degree of Fahrenheit, that alcohol boils at 181, and water only at 212 of the same thermometer. There is formed at its surface a pellicle which gradually thickens, wrinkles, dries and grows yellow in drying. This is caseous matter which separates and becomes solid; when it is removed, and when we continue to evaporate the milk, there is formed a second pellicle, and so on successively. It is observed that these pellicles are thinner and more transparent in proportion as the evaporation advances; they separate in this manner till there remains only a serous and almost transparent liquid in the vessel. In order to obtain and perfectly separate the last portions of the caseous matter in this state of pellicles, we must take care to add, towards the end, water distilled from the milk; when this liquid affords no more pellicles, it is no longer susceptible of coagulation.

When we evaporate the entire milk to a thick consistence, we observe that it undergoes a real coagulation, and that masses are formed in it; its solid matter, when once thickened, assumes a  
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yellowish colour however little we may heat it more ; before it acquires this colour, and when it is still soft, though thicker and more solid than honey, it constitutes *franchipane*, a kind of sweetmeat which is prepared by adding to the milk pounded almonds, sugar, and orange-flowers, towards the end of its evaporation. Formerly the extract of milk was kept for preparing the whey of Hoffman by adding hot water to it. This is almost always a bad medicine, because the extract very easily spoils, and becomes acrid and rancid.

19. When milk is heated in close vessels, and when it is evaporated on the water-bath, a large quantity of water, very little odorous and insipid, is obtained, which presents no phenomena by the re-agents, but which however carries along with it some matters in vapour, since it putrefies, deposits light flakes, and becomes fetid when it is kept. This distilled water was formerly prepared in the laboratories of pharmacy, and great virtues were attributed to it which have at last been discovered not to exist. The milk is thickened and coagulated after having furnished this aqueous product which constitutes nearly two thirds of its weight, when the operation is carried so far as to obtain the residuum in the form of extract. When the extract itself is distilled by the retort it affords a turbid, reddish, fetid water, charged with zoonic acid and ammonia, a pretty abundant quantity of fluid oil of a  
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brown colour, a portion of concrete and empyreumatic oil, of solid and crystalline carbonate of ammonia, of carbonated hydrogen gas and carbonic acid gas. The coal which remains after this operation is considerably voluminous; by incineration it leaves in its ashes some traces of muriate of soda, of muriate of pot-ash much more abundant than the first and of phosphate of lime. Rouelle, who found in milk the presence of pot-ash in the state of muriate, has remarked that this kind of alkali does not exist in the blood, but contains only soda, either pure or combined with muriatic acid. This may serve to prove that another matter besides the blood contributes to the secretion of the milk; and if it affords reason to believe that it is the chyle as proceeding immediately from vegetable aliments—for it is the milk of the cow of which we speak, it announces at the same time that the salts of pot-ash change in passing into the blood. Both these considerations present chemical problems the solution of which is of great importance.

20. Milk exposed to the air quickly becomes covered with a layer of light matter, of a duller white than the entire milk, which itself at the same time becomes more limpid, and assumes a blueish tinge. This white layer, which is of a bland unctuous taste, constitutes the cream; it separates more or less quickly, according to a multitude of circumstances, and in a quantity which, in the milk of the cow, always corresponds

ponds with the goodness and abundance of the nourishment ; hence the poetical expression of fat pasturage. It is more yellow and consistent, the more this nourishment is abundant and of good quality. The cream contains the butyraceous oil, which is not yet butter ready formed, with a small quantity of very light and very bland caseous flakes, and a considerable proportion of whey or serum. Though the cream alone furnishes the butter, it never separates spontaneously and without agitation ; it is known that it may be converted into light and fat cheeses. Cream is one of the products of milk upon which the quantity and quality of the nourishment given by the aliments has the most influence. It is singularly changed, diminished in quantity, and assumes a disagreeable smell in diseases, as is constantly observed in the epidemic diseases of animals. I have observed that the contact of the air contributes much to the separation and the butyrization of cream. It is obtained more speedily in flat and wide vessels, which present a large surface to the atmosphere, than in narrow vessels. I shall revert to this phenomenon in the history of butter.

21. The entire milk, the intoxicating property of which some travellers have announced, especially the mare's milk in Siberia, and that of the ewe in the Hebrides, is susceptible of passing into the vinous fermentation. This art has long been practised by the  
Tartars

**Tartars and the Nomadic nations.** They leave the mare's milk in large buckets, and even mix it with blood, and they obtain from this mixture an intoxicating liquor which they use instead of wine. It has been found, in performing this experiment with care, that the vinous fermentation of the milk does not take place unless when it is in considerable masses; that the integrity of all its elements was requisite to the effect; that it did not establish itself well except in milk of good quality and above ten degrees of temperature; that a slight and repeated agitation of this liquid in close vessels accelerated and favoured it, by mixing well all its materials which tended to separate from each other; that there was disengaged a considerable abundance of elastic vapour, to which it was necessary to give vent from time to time, and that this was carbonic acid; that there was formed a viscid and tenacious scum, a sort of coating at its surface; finally, that the milk, whilst it underwent this intestine and vinous motion became in part acidified and coagulated. When these phenomena have taken place, the milk, which is clotted, of a pungent smell, acidulous and vinous at the same time, being subjected to distillation, by a slight ebullition, affords a product of alcohol in little abundance, and acid at last, which may be rectified by two successive distillations, and presents all the properties of this liquid, which is identical in all cases,

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as it always proceeds from one common source: but its quantity is always so small that it can never be extracted from milk with advantage. It will appear that the slightly saccharine matter contained in this liquor is the true origin of this alcohol, and the cause of the vinous fermentation of which it is susceptible.

22. If the temperature of the air exceed fifteen degrees; if the milk be exposed to the air; if it be agitated in order to retard the separation of the cream and to keep the materials well mixed together, it passes into another kind of fermentation, and acquires an acidity sensible both to the smell and the taste. Every one knows that milk turns spontaneously sour when it is kept for some time; that great changes of the atmosphere, especially electric commotions and tempests contribute greatly to this acidescence: that it is retarded by boiling it, which is attributed to the disengagement of its odorous matter, though it has perhaps no influence upon this property: at the same time that it undergoes this change the milk curdles or coagulates; its constituent materials separate; solid clots more or less voluminous are precipitated from it; frequently even this separation of solid matter takes place in a single piece, and we see a white opaque, semi-concrete mass, shrunk together, and surrounded with a yellowish liquid a little turbid, which gradually augments, and separates from the solid mass in proportion as the particles of the latter approach and condense.

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The portion of the milk thus spontaneously thickened and coagulated is called the curd, and the liquid is denominated the whey. The latter has a sour taste and a pungent odour; it is in proportion and at the moment when it has acquired this taste that the caseous matter becomes solid and separate. In this manner a new acid is formed, which shall soon be examined by the name of *lactic acid*. In the spontaneous decomposition of the milk, and in its separation into solid and liquid matter, we find a remarkable analogy with what happens to the blood; but here it is the product of an acidification which does not take place in the vital liquid, and the comparison if carried too far becomes a real error.

23. Though it be well proved that milk is susceptible of forming by fermentation an acid of a particular nature, it is however not less capable of assuming by a slight modification the character of true acetous acid. Scheele has found that by mixing six spoonfuls of alcohol with about three litres of milk; suffering this mixture to ferment in a well-corked bottle, and taking care to give vent from time to time to the elastic fluid disengaged during this fermentation, the milk was converted at the end of a month into very good vinegar. It is only requisite to pass it through a piece of linen in order to separate the coagulated caseous part, and then to keep it in well closed vessels: it may be employed, like real vinegar for economical and domestic uses.

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We see in this property the consequence of the vinous fermentation and the rapid passage of milk into the state which commonly follows wine, when we begin by adding to it a portion of the essential product of this fermentation: thus is established a very remarkable analogy of nature between the lactic acid and the acetous acid.

24. Milk is coagulated and decomposed by all the acids, the strongest as well as the weakest. Of all the animal liquors it is that which presents the most prompt and easy coagulation. A large quantity of curds more or less voluminous is formed and separated from it at the very moment when an acid is poured into it; when it is concentrated and agitated a little, it produces a solid curd which however divides into flakes by further agitation. Every one knows the use of the weak acids in effecting the coagulation of milk. The curd thus formed and well drained retains no acid taste, and the acid that has been employed remains entire in the supernatant liquor. It is therefore by uniting with the serum that the acids separate the caseous portion, and it is to its tendency to become concrete that the coagulation of this matter is to be ascribed. This we see especially in the curd spontaneously formed, which retains none of the acidity of lactic acid when it has been drained, pressed and washed. We shall hereafter see that this effect is produced by the attraction of the acid in general for the water of the milk, by the little solubility of the  
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insulated caseous matter, and by the little attraction of the acid for this matter.

25. The alkalies do not produce the same effect of coagulation upon milk; though they first separate the cheese from the water, and thicken this fluid at first, because they have a very strong attraction for the caseous substance. Their action upon milk has even been opposed to that of the acids, because when an alkali is added to this liquid once coagulated, the coagulum is actually re-dissolved, by strong agitation. Ammonia especially enjoys this property; it dissolves the curds formed in milk by the acids very quickly and easily: it re-establishes in some measure milk that has been turned in some hot drinks; and it is employed for fusing the milk and causing it to flow in the breasts of lying in women, when they are attacked with that very painful disease the trichiasis. Boerhaave having observed that the *oil of tartar*, or a condensed solution of pot-ash proceeding from burnt tartar, being boiled with milk, gave it a yellow colour which passed into the red, thought that this phenomenon resembled the blood, and that this liquid proceeded from a similar combination between the chyle and the alkaline humours. This effect of colouration, which never goes so far as redness, and is very different from the phenomenon of sanguification, depends upon the re-action of the alkali upon the caseous matter of the milk and upon the transition  
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of this matter into the state of a kind of carbonated oil, as I shall show hereafter.

26. The salts, of whatever nature they may be, have considerable action upon the component materials of milk, in separating them from each other, and it is in this manner that they decompose and coagulate this liquor. It can only be by their attraction for the water that they produce this effect; and we see that the greater this attraction is, the more speedily they effect the coagulation of the milky liquid. Scheele well understood the cause and the presence of this phenomenon.

The metallic salts and solutions act in a complicated manner upon milk, on account of the multiplied attractions exerted by the saline matters dissolved in this liquid; but we must here confine ourselves to the enunciation of their coagulating and decomposing action in general, consisting in the separation of the caseous matter. Other details of their effects belong to the particular properties of the insulated materials of milk, and we shall treat of them in the subsequent paragraphs.

27. It is known by all the economical uses of milk, that this liquor unites easily with several vegetable matters; that combines with gum, sugar, the amylaceous fecula, the aromatics and several colouring matters; that some give it a more or less thick consistence, and agreeable taste, a pleasant perfume, and varied colours. But chemistry shows that these combinations  
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are merely transient, that they take place only at the expense of the nature itself, and of the intimate mixture which constitute this liquid, so that it is more disposed to be altered and decomposed. Scheele has proved that all these matters, dissolved in the milk and especially if heated with it, effect its coagulation and the separation of the cheese. He has constantly attributed this effect to the solution of these matters in the water, and to the superiority of their attraction for this liquid over that which the caseous substances has. Many flowers, grains, leaves and parts of vegetables in general exert the same decomposing and coagulating action upon milk, though the plant which has received the French appellation of *Caille-lait* (*gallium*) possesses this properly in an inferior degree so many others, as Citizens Deyeux and Parmentier have found. Many of these vegetable substances are employed, as we shall see, for insulating the caseous from the serous part. We find the same effect in several animal substances, both mucous and gelatinous, such as the membranes of the stomach of man, of birds, &c. fish-glue, the skins of all animals, whether acidulous or susceptible of acescency, as *runnet*, and animal jelly, and they are employed for the same uses. Alcohol also decomposes milk, and coagulates it into very small flakes, which may be immediately redissolved in water. This separation of the flakes of cheese and butter proceeds, like that  
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of a dissolved salt from the attraction which alcohol has for water.

28. All these chemical phenomena of the entire milk prove that this liquid is a very compound substance, the materials of which are but feebly united with each other. It presents itself as a momentary combination, a kind of suspension of fat and oily matter in a mucous and saline liquid, the adhesion of which is but weak, the equilibrium little permanent, and the principles of which tend to separate by a multitude of causes. On this account milk has been considered as a kind of animal emulsion, and compared to that which is obtained by the trituration of oily and mucilaginous feeds in water, to the thick liquid which is prepared by triturating gum and oil with this fluid; but in order to know whether this comparison affords an exact notion of the nature and composition of milk, the properties of each of its component materials must be examined; namely, the serum, the caseous part and the butter.

## SECTION IV.

*Of the Serum of Milk, or of Whey.*

29. THE serum of milk, or whey, is the most abundant part of this liquid. We do not here treat of what is called *whey* in the dairies, or of the liquor separated by acescence; it is of the serum not turned sour that I intend to speak, and particular processes are requisite for extracting it or separating it from the milk: the following is that which is generally employed with success. The entire milk is heated, rennet being added to it in the proportion of about a gramme to the litre: this substance, proceeding from the residue of the milk coagulated in the stomach of the calf and the gastric juice which is mixed with it, causes the milk to coagulate with facility. It is then suffered to boil for some moments, after which it is passed through a straining cloth: there runs off a liquid still turbid, which is to be clarified with white of egg and agitated in a little water; when it has cooled it is filtrated through a double paper without size. We may employ the membrane of the stomach of birds, or the flower of the thistle, or of the artichoke for coagulating milk. When we employ the tartarous acidule in fine powder, or vinegar, the whey which we obtain

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is not pure, but presents properties that do not belong to that fluid.

30. The whey or the serum of milk thus prepared is a liquid perfectly limpid, of a greenish-yellow colour, of a light faint and sweetish smell when hot, inodorous when cold, of a sweetish, slightly saccharine and unctuous taste. Its specific gravity is a little less than that of the entire milk; Muschenbroeck had estimated it at 1016, the milk from which it proceeded being 1030; Citizen Briffon gives for the specific gravity of the milk of the cow 10,324, and for that of the clarified whey which was extracted from it, 10,193. Previous to its clarification it still contains a small quantity of caseous matter, which impairs its transparency and is suspended in it in flakes. By a mild heat continued for some time, it clears and deposits these flakes. It is also, in this state, turbid, and of a greater density than after its clarification. The density of this purified liquor proves that it is very different from water, which is also confirmed by its colour and taste: accordingly, whey is a very nourishing liquor. Besides those patients who are supported and sometimes even too highly nourished with this animal liquor, the history of the arts presents two remarkable facts respecting this property, which relate to two celebrated men. Boerhaave lived several successive months without any other nourishment than whey, and Ferguson made it his nourishment during eighteen whole years,

adding to it only a simple decoction of barley.

31. The action of heat upon whey affords results different from those which milk presents. When evaporated in open vessels, or distilled on the water-bath, there is separated from it a large quantity of slightly odorous water, which contains nothing sensible to the re-agents, though it becomes altered by putrefaction; the whey becomes coloured, grows brown, turbid, thick, becomes viscous and concrete like granulated honey: if in this state it be heated in a retort, it does not furnish the same products as the entire milk; they have not the same fetidity; they do not contain an equal proportion of carbonate and of zoonate of ammonia; we find in them on the contrary pyromucous acid and ammoniacal pyromucite; the gas is less carbonated hydrogen than carbonic acid; the coal which it leaves is light and burns easily; we find in its ashes a small quantity of carbonate of pot-ash, of muriate of soda, and more of the muriate of pot-ash and phosphate of lime.

32. When we evaporate the serum of milk to the consistence of a syrup, and afterwards let it cool slowly, there are deposited from it irregular crystals of a brown yellow colour, of a fat and unctuous appearance, which, when re-dissolved in water and purified by two successive operations, pass through the yellow tinge and at last arrive at the state of white crystals in regular paralelopipeds. This matter

is, what is called the salt or the sugar of milk ; a substance very remarkable in its properties, and which deserves to be studied with attention.

Kaempfer assures us that the Brachmans have long known the art of extracting the sugar of milk. Fabr. Barthollet or Bartholdi, an Italian physician, was the first who made express mention of it, in 1619. Etmuller, Guterman, Testi, Werloschnigg, Wallerius, Fickius, Cartheuser, Vulgamoze, and Lichtenstein have successively written its history and examined its properties. Rouelle the younger, Scheele, Hermstadt, Citizens Deyeux and Parmentier have especially occupied themselves with its nature and chemical composition. We shall see that notwithstanding the labours of these able men, there still remains something to be desired respecting this singular substance, the formation and the existence of which in the milk present considerations of great importance to the physiologist.

33. The sugar of milk is prepared in considerable abundance in the mountains of Switzerland, a country so renowned for the excellence of its pasturages, and for that of the milk of its cows, as well as its different products. They take the serum obtained from skimmed milk coagulated by rennet, boil it and evaporated it fresh, before it turns sour, till it has acquired the consistence of a thick syrup, and becomes fixed into a granulated matter by cooling. It is then poured into earthen moulds like the boiled juice of the sugar-cane ; in which



it condenses into a mass which is dried in the sun : sometimes it is poured into vessels with flat sides, in which it assumes the form of cakes. It is very impure in this first operation; it is refined by dissolving it in water and clarifying the solution with white of egg; it is boiled again to the consistence of a thick syrup, which is suffered to crystallize gradually by cooling: and thus afford white crystals in rhomboidal parallelepipeds. The mother-water which is decanted from the crystals deposits others of a yellow or brown colour which are successively purified or refined. It is not without great difficulty that some rudiments of crystals of sugar of milk are obtained in the small way in our laboratories; but we separate this body in the granulated and honey-like form. It appears, when we take the average term of the proportions which authors have indicated in the different kinds of milk, that the maximum of its quantity is one-twenty-eighth and the minimum one-sixtieth of the milk.

34. M. Lichtenstein has made the analytical examination of the different varieties, or rather of the different states of the sugar of milk, which are sold at different prices in the Helvetic Republic. The following are the principal of them which he distinguishes:

A. *The white and pure sugar of milk*, extracted from the purified serum.

B. *The acescent sugar of milk* extracted from whey



wey that has turned sour: it is coloured, fatty, moist, and impure.

C. *The sugar of milk mixed with mother-water or fatty parts*, as the author calls them, is that which separates in the first crystallization.

D. *The sugar of milk mixed with oil and muriate of soda*, which crystallizes the last.

E. *The sugar of milk mixed with fat parts, with muriate of soda, and with muriate of ammonia*; this is adhesive and moist; it affords ammonia by the fixed alkalis.

F. Finally, a variety of sugar of milk mixed with all the substances already indicated, and also with an extractive part and caseous matter. This last, the most impure of all, becomes rancid: and in this state it is acrid and pernicious. In France, the different varieties of these sugars of milk are not known.

35. The salt or sugar of milk, when well purified and crystallized, presents to the chemist properties which belong to no other substance. It is white, crystalline, of a faint taste, and seemingly earthy, notwithstanding the name which it bears, unalterable by the air: it is much less soluble than sugar, since four parts of hot water are required for the solution of one part of it; more than twelve of cold water are requisite. Placed upon ignited coals, it becomes brown, fuses not so well nor so speedily as sugar, exhales white fumes, having a pungent odour of caramel, the fumes of which they resemble, swells, inflames, and leaves a black

black coal, less light, rather easy to be incinerated, leaving  $\frac{1}{10}$  (30 grains in the pound) of the weight of the primitive salt, in which Rouelle has found a mixture of three-fourths of muriate of pot-ash, and one-fourth of carbonate of pot-ash. Distilled in a retort, it affords water charged with pyromucous acid, some drops only of red oil, much carbonic acid gas, mixed with carbonated hydrogen gas, and a light coal of the nature already indicated. According to its properties, Rouelle and Vulgamoz have considered it as real sugar. Scheele has confirmed that opinion by converting this matter into oxalic acid by means of nitric acid.

36. But a particular discovery of Scheele, relative to this sugar of milk, has however shown that this kind of mucous body presents a very essential difference from sugar properly so called. In treating it with the acid of nitre, he remarks that it required more to change it into oxalic acid; that it afforded only a little more than one-eighth of its weight of this acid; and that there was gradually separated from it a white powder, little soluble, in which he found the characters of a particular acid which he calls *acid of sugar of milk*, and which has since been designated in our nomenclature by the name of *sachlactic*, and of which I have given the history, under that of *mucous acid*, in the article concerning gum or vegetable mucus, because this substance has, like the sugar of milk, the property of affording it by the

the action of the nitric acid. It has been seen in this article that Mr. Hermstadt, who has inserted in Crell's Annals of Chemistry two Memoirs upon the sugar of milk, believed that the mucous or saccharic acid was oxalate of lime disguised by a fatty matter; but Scheele, who had also suspected the same could not verify it, nor has it received more confirmation from our experiments. From the little taste and solubility of the sugar of milk and its property of forming mucous acid like gum, I consider it as a sort of intermediate substance between the mucous substance and sugar; I believe it to be the product of the work of digestion; for it is formed in the carnivorous animals, in the milk of which it is even abundant, as well as in the frugivorous, and it is difficult to believe that it passes immediately from the stomach into the mammæ by the chyle. Perhaps it may be this muco-saccharine compound which is found in the urine of persons labouring under the *diabetes mellitus*. Citizens Deyeux and Parmentier believe that the sugar of milk, which they assert to be more soluble in milk than in water, is a combination of sugar and saccharic acid, and that it may be formed artificially by uniting these two matters. I have no knowledge nor can I say any thing concerning the experiments upon which they ground this assertion, which I must confess however appears to me to accord very ill with what we know of the properties of  
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of the two substances which they suppose to be combined.

37. When we have obtained all the sugar of milk contained in the serum, the liquid which remains as mother-water is brown, viscous, thick, and gluey; it affords by cooling, as Rouelle the younger remarks, an almost transparent jelly, and it concretes into a tremulous mass, like an animal decoction. It is in this mother-water also, that several saline matters exist, which may be separated from it, if after having diluted it with a small quantity of water, it be evaporated very gently, and with the attentions with which experiments of this kind ought to be conducted. They are cubes of muriate of pot-ash which deposit themselves thus in the crystalline form: the phosphates of soda and of lime, which form part of the deposit, and which other experiments enable us to discover in it, are too little abundant and too much disguised by the former crystals, to be perceptible in it. The re-agents by which they are indicated present particular phenomena with the entire milk previous to its evaporation or concentration; these are the alkaline and metallic solutions. Lime-water, the solution of strontian and of barites precipitate the serum of milk very sensibly; the precipitate is an insoluble earthy phosphate. Pot-ash, soda, and ammonia form in it a light mass, which is only precipitated phosphate of lime. Amongst the metallic salts, the nitrates of mercury and silver  
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are those whose action upon the serum of milk has been the best examined. The first forms in it a precipitate of a greyish-white colour, which becomes rose-coloured by drying in the air; the second, in precipitating it, remains in a white powder. Both these precipitates afford traces of phosphorus when they are distilled alone or with pulverized charcoal at a sufficiently elevated temperature. They are composed of metallic muriate and phosphate coloured and soiled by a gelatinous animal matter. The action of the acids upon whey, has nothing remarkable; the concentrated sulphuric acid colours and reduces it to coal; the nitric changes it into oxalic and sacchatic. The concentrated whey turns syrup of violets green: Rouelle the younger attributed this colour to the yellow of the liquor.

38. We see that by the preceding re-agents the serum of the milk is altered only as to its saline substances, that they alone produce the effects announced, and that the muco-saccharine and gelatinous substances, which however constitute its principal materials, (for the salts amount in it only to some thousandths,) experience no change or alteration, at least not perceptibly by their precipitation by means of these re-agents. Indeed it cannot be doubted that the caustic alkalies and the powerful metallic salts act upon these two organic substances, as is indicated by the change of the colour of the fluid, and the colouration of the

the precipitates; but these slight modifications are but little appreciable. Thus the object of the chemist, in treating whey by the re-agents, is particularly to exhibit its saline properties. There are, however, also means, without other re-agents, of separating and obtaining distinctly the mucous and gelatinous compounds, and of distinguishing them from each other, and from the saline materials that are mixed with them. When the serum of milk thickened and concentrated by fire has acquired the consistence of a thin syrup; if we throw into it a sufficient quantity of alcohol, a flakey and mucous deposit is formed which contains the sugar of milk, and the gelatin, equally insoluble in this liquid, and separated from the water by reason of the strong attraction which it has for alcohol. The serum thus thickened may be precipitated, though little abundant, by tannin which seizes only the gelatinous substance which it contains, and we may afterwards find again in it the mucosofaccharine salt which it contains by the addition of alcohol, which precipitates it in its turn.

39. I have strongly insisted in my experiments on the analysis of the serum of milk upon the presence of the phosphate of lime, which, by its quantity, has appeared to me to follow immediately after the muriate of pot-ash. We find it in the ashes of whey when entirely evaporated and burned, or in those  
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of the coal which it leaves after its distillation. It is this which is precipitated by the addition of pot-ash, of soda, and of ammonia, in well clarified whey, and the precipitation of which becomes much more sensible which this humour has been previously concentrated by evaporation. The oxalic acid which constantly renders the serum turbid, and forms in it a precipitate of oxalate of lime, affords also the proof of its existence by the earthy base which it takes from it: the phosphates of mercury and lead which are obtained by the nitric solutions of these metals, and which contain its acid, complete the proof. The little solubility of this salt, and its existing nevertheless in the proportion of several thousandths in milk, prove that it enters into the plan of nature to furnish it constantly to the young animals in this first nourishment which they take so greedily and so abundantly. I have thought I had found the reason of this view of nature in the rapidity and energy of ossification at this tender age of life.

40. One of the most characteristic properties of the serum of milk is that it turns sour with great facility: perhaps it passes previously into the vinous fermentation; but this is so feeble and slight, that it is difficult to seize the instant of the transition. The acescence on the contrary is the most constant and the most marked phenomenon which this liquid presents in the course of its spontaneous alterations. It is by  
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this motion that the lactic acid is formed. The whey commonly becomes turbid and deposits some light flakes of caseous matter in proportion as it becomes sour: if we add two or three spoonfuls of alcohol to each litre of this serum, we obtain acetic acid instead of lactic acid, as with the entire milk. I have already remarked that Scheele in examining milk that had spontaneously become sour, discovered a particular acid in it: he has given both the means of purifying it and the history of its principles and combinations. No chemist has added any thing to the work of Scheele. It is proved that the formation of this acid is owing to the alteration of the sugar of milk or of its mucoso-saccharine matter; for when this acid is once well formed, when the whey having become strongly acid intensely reddens the blue vegetable colours, we no longer obtain this matter from it by evaporation and crystallization.

41. Scheele not having been able to succeed in separating the acid of sour whey by distillation, but having obtained by this operation only a little acetic acid, the formation of which appears constantly to accompany that of the lactic acid, endeavoured to obtain this fixed acid by other means. The following is that which succeeded the best with him, and which, though complicated, proves the sagacity and extensive resources of this able chemist. Sour whey is evaporated to an eighth of its volume by

by a very gentle fire; it is filtrated in order to separate from it all the caseous matter thus coagulated in flakes; lime water is added to precipitate the animal earth, that is to say, the phosphate of lime; it is then diluted with thrice its weight of pure water, and the excess of lime is precipitated from it by the oxalic acid, the latter being added in no larger proportion than is necessary, and so that an addition of lime-water shall form in it neither cloud nor streaks; the liquor is evaporated to the consistence of honey, alcohol is then poured into it, which separates the portion of sugar of milk or other extraneous matter, and dissolves the lactic acid; lastly, the liquor being drawn off clear is distilled till all the alcohol that has been added is collected: and what remains in the retort is pure lactic acid. The following are the specific and characteristic properties which the Swedish Chemist has found it to possess.

42. It has a rather strong sour taste which is not agreeable; it is in the liquid and viscid form when concentrated; it reddens the tincture of turnsole well, and it gives a violet-red tinge to the syrup of violets. Evaporated even to a very dense consistence, it does not assume either the crystalline or granulated form; but it has a muciliginous viscosity. Distilled in a retort, it affords a pretty strong empyreumatic acid analogous to the pyrotartarous, with very little oil, and the carbonic acid and carbonated hydrogen gases, and a coal in little abundance adhering to the glass.

glafs. When united with the three alkalies, with barites and with lime, it forms falts little cryftallizable and deliquefcent. Its combination with magnesia cryftallizes, but it alfo attract the moisture of the atmofphere: moft of thefe earthy and alkaline lactates are foluble in alcohol. The lactate of ammonia is not known, neither are thofe of alumine, of glucine and ftrontian; what Scheele has given us relative to the properties of thefe falts is ftill only a firft notion. We find in it nevertheless relations with that of the acetites: however the lactic acid decomposes the acetites.

43. The combinations of the lactic acid with the metallic oxides have alfo occupied Scheele; but he ftudied only what appeared to him to be neceffary for diftinguifhing and characterizing the lactic acid, and he had not the intention of examining their complete feries: fo that his work presents in this refpect only a flight outline of what the fcience requires. According to his enquiries, the lactic acid does not in any manner attract cobalt, bismuth, antimony, mercury, filver and gold, notwithstanding the long duration of contact between thefe bodies and even with the aid of ebullition. Zinc and iron are oxidized and diffolved in it, as in almoft all the acids, with difengagement of hydrogen gas: which announces that they decompose the water, that the lactic acid augments their attraction for the oxygen, that it favours and accelerates the decomposition of the water,  
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and that these two metals contract no adhesion with it till after they have previously been oxidized. The lactate of zinc crystallizes ; that of iron forms only a brown deliquescent mass. The same acid oxides and dissolves lead and copper. Frequently, during the solution of the first of these two metals, a small quantity of sulphate of lead is precipitated, which announces the presence of a small quantity of sulphuric acid in this acid.

44. We see, according to this faithful exposition of the labours of Scheele upon the acid of soured whey, how much is still wanting of facts in order to make us thoroughly acquainted with its properties : those which he has described are merely sufficient to prove that it is a particular acid different from all others. Besides the great number of its saline compounds which are still wanting to the science, Scheele has not indicated the action of fire upon this acid, its spontaneous alteration in the air, its habitudes with the nitric acid, &c. : it is not known whether it is totally decomposed by the latter or converted into another acid, especially the oxalic, as several vegetable acids are. Its intimate nature and composition are entirely unknown : though it presents properties which approximate it to the acetous acid, and which may lead us even to believe that it is very similar to it, I still find it impossible to rank it amongst the vegetable acids. On the other hand, I find it equally impossible to adopt a decided opinion relative

relative to its animal nature, since no experiment has hitherto exhibited the presence of azote in it, and since it is unknown whether it can afford ammonia in its decomposition, whether it is putrescible, whether it can be converted into Prussic acid, as we know can be done with all the well characterized animal matters. It must therefore be a subject of research for chemists, if they wish to acquire a more positive knowledge concerning it.

45. It may be inferred from all the facts contained in this paragraph, from all the analytical experiments upon the serum of milk or whey, of which I have just given an account, that this liquid is composed of a large quantity of water, of a variable proportion of mucoso-saccharine crystallizable matter, of gelatin and of some saline matters, especially muriate of pot-ash, perhaps of sulphate of pot-ash and phosphate of lime; that the two first substances render it sweet, saccharine, susceptible of fermentation, of acescence, of affording nourishment, of crystallizing, of concreting into a jelly, of being precipitated by tannin; that the salts, and especially the phosphate of lime are the causes of its precipitation by the alkalies, of the traces of phosphorous which its metallic precipitates treated by an intense fire yield; that the knowledge of these constituent materials explains its nutritive quality and its special advantage as the first aliment of young animals; that this composition of the serum of milk may be regarded with respect to it two  
most

most abundant principles, the mucofo-faccharine substance and the gelatin, as the natural link which contributes to hold a slight combination with the other materials of the milk, and especially the butter; finally, these two matters perform in some measure the office of the gum in loches, or of the mucilages in the emulsions of vegetable seeds.

## SECTION V.

*Of the Caseous Matter and of Cheese.*

46. THE caseous part of milk is obtained by means of a great number of different substances which have the property of turning or coagulating it. In order to obtain this substance pure, we must be careful to take skimmed milk, that it may not be mixed with butyraceous matter. Runnet, the flowers and the receptacles of most of the composite or synginesian plants, and all the astringent plants, have the property of curdling or coagulating milk in the cold with the aid of a little time; the acids, whatever they may be, have the same property; and as they remain dissolved in the serum, we may employ them, provided we use them weak and in small quantity, for obtaining the caseous part. We may also employ the dried membranes of the stomach and intestines of animals, glues, Vol. IX. L1 jellies,

jellies, and membranes, which produce the same effects. We have already seen that alcohol also acts in the same manner in the decomposition of milk. The caseous substance is separated, either in the form of small insolated flakes, or in that of a kind of tremulous matter in a single white and opaque piece, or in that of thick masses which tend to condense and harden.

47. In dairies the milk is turned by different means, but especially by runnet employed cold, for preparing cheese. These are in general of two kinds accordingly as they have been prepared either with entire or pure milk, or with skimmed milk. The first constitute the fat unctuous cheeses, which retain a softness and opacity, which have a fine and sweet paste, and by a slight alteration run and form a sort of thick syrup, as we see in the good cheeses of Brie. Skimmed milk affords a hard and solid caseous mass, which becomes dry and brittle, and, when strongly compressed acquires a semi-transparency and constantly preserves its solidity, growing hard instead of softening and running. In order to fabricate and preserve them they are put to drain upon hurdles, they are salted and kept in low and moist situations, they are sometimes inclosed in hoops of thin and flexible wood or bark, which are bended round their sides and closed every day so as to diminish their diameter; they are also salted at their surface. By these processes the water of the caseous matter is pressed out, its flakes are

are brought nearer together, and they are made to acquire a homogenous consistence throughout their whole continuity.

48. There are many differences in cheeses, according to the diversities of the milk, the nature of the runnet which is employed for separating and precipitating them, the art of pressing, kneading, draining, drying and exposing them to different degrees of alteration or of fermentation ; according to the quantity of whey which is left in them, the force of pressure which is employed, the temperature to which they are subjected, the kind of package or piling which they undergo, the time during which they are treated in this manner ; lastly, according to the general combination of all the circumstances which preside in some respect over their preparation. In order to obtain cheeses with a dry, dense, semi-corneous and semi-transparent paste, like those of Gruyere; the caseous matter being separated from the coagulated milk is kneaded in the hands : after it has been properly worked, it is drained upon hurdles or compressed and kneaded anew ; the cheeses are pressed and the serum forced out of them, not only moveable by the hoops which are brought closer every day, but also with weights placed upon them after they have been piled one upon the other ; when once dried they are salted at several times ; the white and blue mould which forms upon their surface



is repeatedly scraped off; this is discontinued when this mould formed upon the dried rind has assumed a red colour; the fermentation is conducted slowly and gently till it has communicated to the cheeses the taste and smell which ought to characterize them. This operation is performed in subterraneous buildings, or cool vaults, and at a constant temperature of between 2 and 5 degrees  $\pm$  0. Such are the so famous cheeses of Roquefort.

49. It is not upon these cheeses prepared by art and more or less altered by a fermentation which none of them escapes, and which is constantly observable in all or almost all these alimentary preparations, that chemists make the experiments proper for ascertaining the properties. It is to this matter in its fresh state, not altered but still natural, such as it is precipitated from the milk at the very moment of its decomposition, that they direct their attention, and upon which they perform their experiments. The caseous substance, which is not yet cheese, obtained in this manner and well pressed, is in the form of white granulated flakes, easily separable from each other, susceptible however of being crushed under the finger like a sort of paste, of a sweetish taste which is not disagreeable. It powerfully retains the last portion of serum lodged between its interstices, and a great degree of pressure is requisite in order to dry it completely; it is then dense, brittle, and begins to assume a semi-transparency: in this  
state

state its aspect presents the notion of a concrete albuminous substance. The average quantity of the caseous substance is estimated at  $\frac{1}{10}$  of the entire milk. There are great varieties in this proportion,

50. The caseous matter, well condensed, kneaded and deprived of all the serum by pressure, and well separated from the butyraceous substance, in consequence of being extracted with care from skimmed milk, exposed to a gentle fire gradually augmented, softens, becomes ropy, and as it were glutinous and elastic; if acted upon by a stronger fire it entirely melts, swells, becomes brown, exhales a thick fume of a very fetid and strongly ammoniacal smell, and at last takes fire, flashes of white and brilliant flame escaping from several points; it leaves a pretty dense coal. If we distil it in the retort, we obtain a red, turbid and fetid water, charged with zoonate and carbonate of ammonia, a very thick oil, almost concrete, of a deep brown colour and of an insupportable smell, concrete ammoniacal carbonate foiled by a little oil, much carbonated and sulphurated hydrogen gas, with carbonic acid gas, and a hard coal, adhering to the glass, brilliant, difficult to be burned, the ashes of which present in analysis only a little muriate of soda, and the greater part phosphate of lime. No carbonate of soda or metallic oxide is found in it.

51. Exposed to the air in its dry state, the caseous matter remains and is preserved without

out alteration; but if it retains a portion of serum between its parts, it first turns sour at a temperature exceeding 12 degrees; it afterwards putrefies, softens at its surface; there flows from it a kind of fetid fumes; ammoniacal gas is disengaged from it, and insupportable fetid odour, that subsists for a very long time, very tenacious and which appears to be owing to a compound gas, that escapes but very slowly and with much difficulty; it passes at the same time through several successive tinges, orange, red, brown, blue, &c. Every one knows the horrible infection diffused by old or putrefied cheese, and the adhesion, the kind of fixity which this odorant substance acquires upon different bodies, the wood-work and even the walls which are impregnated with it. The total decomposition of this substance is of a very long duration, and it presents, like the flesh and other animal substances already indicated, a fatty and very fusible body, reduced to an ammoniacal state by the ammonia, the complete destruction of which lasts for a great length of time: the contact of water in abundance abridges its duration.

52. Cold water scarcely dissolves cheese at all; it holds its most divided flakes for a longer or shorter space of time in suspension; boiling water, without really dissolving it, softens it and contracts a pretty strong adhesion with it. Scheele has observed that the caseous substance,  
precipitated

precipitated by an acid foreign to the milk, is partially soluble in boiling water; but this solution does not succeed unless it be effected at the very moment when the substance has just been precipitated: if we leave its flakes for some time to unite and condense, it is no longer possible to accomplish it. When the caseous matter has remained for a sufficient time in cold water, we find it converted into a fat, unctuous, fusible body, very soluble in the caustic alkalies and of a fetid smell. Water therefore accelerates the spontaneous decomposition to which this animal matter is naturally so much disposed. This is the reason why dry cheeses, exposed in moist places, soften, increase in weight, acquire a smell, a taste, in short a state, different from what they had at first; it is in this manner that they are matured according to the common expression, and those qualities are given to them which are so much in request amongst persons who prefer of this kind of food.

53. The powerful and concentrated acids act rather strongly upon the caseous matter, and dissolve it easily with the aid of heat; but if diluted with water, or naturally weak, they do not by any means exert the same action upon it. The nitric acid turns it yellow, disengages from it azotic gas, Prussic acid and carbonic acids, and changes it partly into fatty matter, partly into oxalic acid. There is also formed a small quantity of bitter matter, which adheres  
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in a great measure to the yellow oil and which colours the fingers.

The caustic alkalies, in highly concentrated leys, alter the caseous matter at the very moment of their contact; and separate from it azote and hydrogen, which immediately unite into ammonia, and they convert its residuoual portion into a kind of oil with which they unite in the saponaceous state. Ammonia dissolves the caseous matter rapidly and abundantly when recently precipitated or coagulated, and this solution is considered as one of the most speedy and powerful. Quick-lime forms with this matter, when still humid, a kind of paste susceptible of great solidity and adhesion: this mixture is employed as one of the best cements for porcelain. There is reason to believe that a still more solid cement might be made with barites and strontian.

54. The salts have not the same solvent action upon the caseous matter, but almost all of them oppose its spontaneous decomposition; accordingly the muriate of soda is more especially employed both as a means of preservation and as seasoning, in order to make the cheeses keep, and to retard the septic alteration which tends to destroy them. An old prejudice, which I have already combatted, has caused it to be asserted that the small quantity of this salt accelerates their fermentation; but it is easily found by observation that it is not with the intention of favouring

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ing it that this saline condiment is employed, but rather with that of limiting it, by covering the surface, by absorbing their humid portion, by concentrating their commencement of their septic alteration in their centre, or confining it to their exterior part, according to the soft or solid nature of these preparations. The same is the care with the oxides and especially the salts of metals, which condense, contract, dry, and consequently preserve the caseous matter, either by the approximation of its molecules, or by absorbing its humidity, or by preserving it from the external moisture.

55. Many vegetable substances are susceptible of uniting with the caseous matter when fresh, soft and humid; it is rendered miscible with water by triturating it with mucilages; it adheres to the saccharine substance; it becomes charged with several colouring matters; it unites by trituration with the fecula; it combines with tannin, and becomes hard and dry in this tanned combination. Its habitudes with the animal substances are as yet not well known; no attempt have yet been made to determine its relations with the albuminous and gelatinous liquors, with the fat juices, with fibrine, with the most complicated animal liquors, though it is easy to be conceived that inquiries of this kind might procure an acquisition to animal philosophy, by ascertaining the miscibility, the solubility, the re-action and the reciprocal alteration which those different organic

organic compounds may present amongst themselves. It is very evident that this caseous substance is intimately mixed with the butyraceous oil and the gelatin in milk, and that it is to these substances that owes its solubility or adhesion with water, which forms the vehicle of the different materials of this liquid.

56. All the lights that have been acquired relative to the properties of the caseous substance have induced modern chemists to think that this substance has a remarkable analogy with albumen; and in fact it is amongst the different animal materials that which the caseous substance resembles the most in its coagulation by the fire and by the acids, its solubility in ammonia, its products in distillation, or its alteration by the nitric acid. But notwithstanding this analogy, there are however some remarkable differences between the albumen of the blood and the caseous substance, which indicate, that though the latter proceeds from the blood, it has undergone in separating from it, and in order to assume the milky form, a modification which has not yet been appreciated. Citizens Deyeux and Parmentier believe that it is to the caseous substance that the milk owes its opaque whiteness, and not to the oily particles suspended by its combination with them, that it is consequently inaccurate to compare milk to an emulsion. If they possess facts in support of this new mode of considering the union of the caseous part with  
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the water, we should see in the opacity of this solution a sufficiently demonstrative indication of a more advanced oxigenation in this species of albumen of the cheese, than in the other known species of this animal matter. We should even find here a rather singular analogy between the caseous albumen whitening water by its solution and the cerebral albumen which dilutes in it, partly dissolves in it, and equally gives to water the emulsive appearance.

Rouelle the younger has established a marked analogy between the caseous matter and the glutinous substance of the flour of wheat; he succeeded by salting and kneading the latter with muriate of soda and a small proportion of diluted starch, in giving to the farinaceous gluten most of the characters, the taste, the smell, the unctuousity of cheese, and he exhibited in his lectures specimens, which by this preparation, had acquired the properties of old cheese in so characterized a degree that it was no longer possible to distinguish them from it.



## SECTION VI.

*Of the Butyraceous Matter, and of Butter.*

57. I DISTINGUISH the butyraceous matter from butter, because the first, being contained in the milk at the moment when it is formed, is not yet butter, and because this last exists only when the milk has remained for some time at rest after having been drawn from the animal which affords it. It is with this substance relatively to these two states as with the caseous part and cheese: the first, being contained ready formed in the milk, may be separated from it without intimate alteration; but it becomes cheese, as we have seen, only by undergoing a more or less considerable modification and change, from even the freshest cheese to that which is the most advanced or the nearest to its putrid decomposition. Butter presents in its separation and formation a still more considerable difference from the milky state than the caseous matter does, at least as far as concerns its mere precipitation from the milk. It is upon this remarkable point in its history that I shall first dwell, as it has not yet been properly treated by the chemists who have gone before me. In 1790, I published, according to a series of experiments  
made

made in the course of the lyceum of this year, a new point of theory, relative to the formation of butter. I remarked that the cream was formed more abundantly in the air than in close vessels and in vacuo; that it was necessary it should remain exposed to it for some time, in order to render it capable of affording butter; that butter could not be extracted from recent cream; that in proportion as it remained in the air, it became more solid, condensed, and assumed a yellow colour; that it required at least four times longer space of time to separate the butter from cream formed in twenty-four hours, than to extract it from cream eight days old; and that all this proved an action of the air, which contributes to the formation of the butter, to its concretion, and separation.

58. The production of the butter is to be understood in the following manner, according to the constant facts well known in all dairies and farms. The butyraceous matter, contained in the milk in the state of a liquid, and white oil, suspended in the serum, with the aid of the mucofo-saccharine body, and of the caseous substance, separates, by means of repose, and swims at the surface, with a small portion of serum, and of caseous flakes, to which it adheres. This compound, which is more oily and more light than the serous and caseous liquor, in proportion as it obtains the contact of the air by remaining above this liquor, absorbs the atmospheric oxygen, becomes solid, concrete, coloured;

coloured; in short, real butter. However, butter may be prepared with milk newly drawn, by agitating it for a long time; whence I conclude, that there is in the milk a sufficiency of oxygen to saturate the butyraceous matter by this percussive action. On the other hand, there are some creams, from which butter cannot be extracted by churning them for a great length of time, and which we are obliged to abandon as to that purpose. In general the cream is left exposed to the air for five or six days before the butter is churned; and in the great rural establishments, this operation is performed only twice every decade: there are many varieties in the properties of milk, relative to the quantity and the quality of the butter which it affords, and still more particularly with respect to the facility with which the butter separates from it. A connected series of observations, and some single experiments, would be requisite, in order to determine the cause of these varieties.

59. Chance first presented the separation and concretion of the butter in agitated milk: the skins in which the Tartars, and the pastoral nations transport their milk, whilst they incessantly change their abodes, and wander in the deserts with their beasts, must have exhibited to them this product concreted into solid lumps by agitation and percussive action against the sides of these vessels; and the agreeable taste of this product must have recommended its use, and dictated

dictated to them the art of providing themselves with it; accordingly, we find traces of it in the most remote antiquity, which are lost even in the first traditions of the human race. The mode of churning the cream, or the butter, varies according to the countries, and the quantity of it that is fabricated: it is in general by turning or moving with rapidity, an axis provided with fans, or kinds of agitators, in vessels more or less capacious, which are in part filled with cream. They are kinds of churns; the former fixed horizontally, the latter placed vertically, which serve for the operation. During a percussive, or rotation of some hours, the motion of the axis, and of the fans which it bears, after having been gradually impeded, is suddenly stopped by the mass of butter which adheres to it, and attaches itself entirely to it. This mass is afterwards kneaded in water, in order to separate it accurately from the portion of whey and of caseous flakes, which are interposed in it.

60. We see from this description, that butter is obtained from the milk but slowly, and by means of a long and violent agitation, which modifies the butyraceous matter, by causing it to absorb a portion of the oxygen of the milk; that it is much easier to be prepared with cream, and that a much less considerable percussive then effects its concretion; that older the cream is, the more speedily the operation is performed; that the butter does not therefore

therefore exist ready formed in the milk ; and that at the moment when it is saturated with the oxygen it requires, the butyraceous matter is converted into butter and quickly concretes into a mass, which no longer adheres to the serous liquor of the cream, because the attraction between its own particles is more considerable than that which it has for the other principles of the milk. When this production, and separation of the butter have taken place, there remains a yellowish liquor, sometimes of a slight orange colour, which is called butter-milk : it is more fluid than milk that has not been deprived of its cream, of a mild and agreeable taste, altogether similar in its nature to milk that has been entirely deprived of its cream. Citizens Deyeux and Parmentier have made a particular examination of it: they have found that butter-milk is coagulated by runnet with great difficulty, that the acids and alcohol separate caseous matter from it easily and speedily in very fine flakes ; and that it has a very great disposition to turn sour.

61. Butter, thus prepared, is generally of a yellow colour: there is some which is white, like a kind of fat ; this is considered as inferior to the former. It is believed that this difference of colour depends upon the nature of the aliments ; but it is well known to the country people, that it depends upon the diversity of the individuals that afford the milk ; that one cow will constantly give white butter, and another

other yellow butter. The contact of the air also influences the colouration of the butter; old cream affords yellow, and new cream paler butter. The lumps of butter exposed for sale, are of a deeper yellow colour at their external surfaces, than in their interior parts. Fresh butter has a sweet and unctuous taste, which is very agreeable, and on account of which it is employed as a seasoner: the difference of the food of the animals has much influence upon this property of the butter. Its soft and very ductile consistence, though in general it is concrete, varies also according to a great number of circumstances. All the physical properties of butter are subject to vary according to the same circumstances.

62. Very fresh butter melts at a temperature of 29 or 30 deg. Reaumur. When we keep it melted in a tube of glass, plunged in boiling water, there separates from it, and swims at the surface, a white liquid, filled with small opaque flakes, which are a mixture of serum of milk, and of caseous matter. By this separation, the butter becomes almost transparent; but it has then lost its sweet and unctuous taste, and it has become fatty and insipid: whence it results, that fresh butter owes its sweet, agreeable taste, to a portion of a serum, and of caseous matter. Accordingly, melted butter, with whatever caution it may be prepared, becomes more greasy, of a granulated consistence, and of a

taste infinitely less agreeable than that which it had before. If the butter has been heated only to the temperature necessary for melting it, it fixes as it cools, and presents no signs of alteration. When distilled in a small retort, it affords some drops of water, rendered acrid by the sebatic acid which it contains: the greater part of the butter rises and passes over entire, with a strong pungent, and very disagreeable smell, as we see in culinary operations, where so many dishes are prepared with browned or scorched butter; much carbonated hydrogen gas is disengaged, and there remains only some traces of a dense coal, difficult to be burned, and containing scarcely any thing else than a little phosphate of lime. By re-distilling the products of the butter, we render the oil lighter and more volatile. If we distil it in a very large vessel, containing much air, we obtain more water, more sebatic acid, a less concrescible oil, more of gaseous fluid, and more coal, since the air of the apparatus contributes to the destruction of the butyraceous matter by furnishing its hydrogen with a quantity of oxygen sufficient for burning it. The sebatic acid is not contained in the butter but is formed here, as in distilled fat, at the expense of its decomposition, and of another arrangement of its principles.

63. Butter suffers from the contact of hot air, an alteration which renders it acrid and odorous. This rancidity proceeds from the

formation of sebacic acid, which takes place with considerable celerity. Washing with water, and with alcohol, deprives the butter of a great part of those disagreeable properties.

Butter unites by fusion with phosphorus and with sulphur, in the same manner as fat does.

The acids likewise act upon it in the same manner; the concentrated sulphuric turns it brown, and reduces it to coal; the nitric yields to it a portion of its oxygen; the others have no action upon it.

The alkalies dissolve it very well; soda forms a solid soap with butter, which might be employed with advantage in medicine. Barites, strontian, and lime, harden it by combination. Ammonia, also, approaches it to the saponaceous state, but leaves it liquid. The soaps of butter, when burned and calcined, afford alkaline, or earthy sebrates, like fat: and these sebrates are also produced by the action of the fire.

The metallic oxides unite with butter, by the aid of fire, and form with it metallic soaps, little or not at all soluble, of a plastic consistence. In the heat it decomposes the metallic solutions, and takes from them, especially from the nitrates, the oxides with which it combines.

64. Amongst vegetable substances, butter unites with the extracts; the gums, and sugar, triturated with it, render it miscible with water; it combines easily by fusion with the resins, the gum-resins, and the balsams; it dis-



solves easily in the fixed and volatile oils ; it absorbs camphor, and retains it strongly ; it attracts several colouring matters, with which it adheres forcibly. The last-mentioned property has long been employed for giving butter a more or less intense gold colour ; for this purpose, carrots, the curcuma, the marigold, the seeds of asparagus, the berries of solanium kalicacabum are used. The colours of butter may be greatly multiplied, and singularly varied. The root of the alkanet gives it a brilliant rose colour, the violet a dull, but pretty intense blue ; the leaves of spinnage, a brilliant green colour. The processes consist in mixing the colouring matters, pounded or chopped, with the cream before it is churned ; the colour thus passes into the butter at the moment when it becomes concrete, but not before this period. Butter, coloured in this manner, keeps for a long time ; it is even difficult to discolour it. We may also cause these different colours to pass into the butter by means of fusion ; but butter, coloured in this manner, cannot serve for a seasoning. The highly odorous matters unite with butter with facility, and we may perfume it by their mixture at the moment when it is churned, with cinnamon, cloves, nutmeg, mace, orange or lemon peel, vanilla, &c. ; but very little must be used, in order to communicate to it a perfume, without acrimony.

65. It may be concluded from all that has  
been

been stated, that butter is a kind of concrete and oxygenated oily humour, resembling fat, and not a vegetable oil, united with an acid, as was formerly believed; that this substance, without being entirely constituted butter in the milk, has, however, a great disposition to become such, and to separate from this liquor in proportion as it absorbs oxygen from the atmosphere, when milk, and still better when cream, is agitated in contact with the air; that butter, which owes its qualities as fresh butter to the mixture of a small portion of serum, and of the lightest caseous matter, and loses them by the slightest fusion, comports itself afterwards like a kind of fat, in all combinations, as well as in all the analytical processes to which it is subjected; and that lastly, there is reason to believe, according to these chemical phenomena, as well as from the anatomical observations of the celebrated Haller, that the fat which every where surrounds the mammary glands, contributes, by means of the ducts described by this great anatomist, to the formation of milk, probably by furnishing it with the basis of the butyraceous matter, whilst the lymph gives it the muco-saccharine principle; and the blood, the albumino-caseous substance, as well as the salts which are dissolved in it.

## SECTION VII.

*Of the different Kinds of Milk, compared with that of the Cow.*

66. In the general examination of milk, and of its different parts, which has hitherto formed the object of this article, I have taken the milk of the cow as an example, as a mean term of all these kinds of animal liquors, as that which is most frequently employed, and for the greatest number of uses, because it is procured more abundantly, and more easily than any other. But it is equally useful, and even necessary for many circumstances of life, to know the characters and the nature of the other kinds of milk which are employed, either often, or only sometimes, as aliments, or as medicines, or as objects of rural manufactures, and the subjects of products advantageous to whole countries. We must therefore compare together the milk of woman, and those of the ass, the goat, the ewe, and the mare; all of which, when referred to what I have said concerning the milk of the cow, will require nothing more than the simple exposition of their differences. Most  
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of the authors quoted in the beginning of this article, have spoken more or less concerning those differences; but none have made them the object of more attention and study than citizens Deyeux and Parmentier. I shall therefore more especially follow them in giving the specific characters of each kind of milk, attending, like them more to the quality than the quantity of their principles; because the latter, varying according to a multitude of circumstances, present nothing constant to the observer.

#### *A. Woman's Milk.*

67. The milk of the woman is generally known to be less thick, less opaque, and more saccharine than that of the cow. Its colostrum frequently resembles thin soap water; repose, causes fat and unctuous flakes to swim upon it, from which no butter can be extracted by agitation. The liquor, after this separation, is scarcely opaque, becomes viscous, sour, putrefies, and appears to contain little caseous matter: such is the colostrum of the first day. That of the second, which is whiter, affords a kind of flakey cream, which does not yield butter any more than the preceding; that of the third and of the fourth day assumes the character of real milk, still without the possibility of extracting butter from its cream: the acids coagulate it well, and its serum is easily clarified.

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The well-formed milk, examined at different periods till the eleventh month after lying-in, presents varieties, even at different times of the day: it, however, gradually diminishes in quality, in general, proportionably to the length of time that has elapsed since delivery. Its cream, which is very abundant, sometimes does not admit butter to be separated from it; it is then very liquid, unctuous, and seems to contain an oil that is not concrescible.

68. When the cream of woman's milk is thick, it affords by agitation firm butter, a little yellowish, of an ordinary taste, and in small quantity. All the processes which coagulate the milk of the cow, produce the same effect upon that of woman; the cheese is in general softish, unctuous, and does not acquire the same concrete state. The clarified serum is scarcely coloured, its taste is more saccharine than that of cow's milk; it contains only a little more of the mucoso-saccharine principle; Haller, however, has indicated its proportion to that of the cow, according to Navier, Hoffman, and Yonna, as 67 to 54. This serum is less compounded than that of the cow, it contains less salts, and it is to this circumstance that citizens Deyeux and Parmentier attribute its more saccharine taste. There is no milk that shows itself more variable in its analysis than that of woman. Upon the slightest change in the state of the health, it loses its consistence;  
after

after spasms it contains no more caseous matter; it is then repugnant to the infant, who does not take the breast again till when the milk has returned to its natural state. Thin and delicate women frequently yield stronger and more abundant milk than fat women. It is known with what facility the medicinal, and particularly the purgative properties, pass from nurses to their sucklings; this is much more remarkable in women, than in the female animals.

69. Citizens Deyeux and Parmentier have examined even the differences which arise from the different methods of suckling the infants. According to their observations, great inconveniences arise from making them suck often, and letting them take only a small quantity of milk at a time: it is then always too serous. Women, who without being aware of this, and in order to mitigate the cries of their infants, acquire the bad habit of giving them suck very often, and thus afford them always a too liquid or serous milk, in small quantities at a time, are much more subject than others to repletions of the breasts, and all the affections which depend upon the alteration and detention of this liquid in the mammary ducts. It appears that a phenomenon here takes place analogous to that which is observed in milking cows at divided periods; it has been seen that the first milk is the most serous, the least thick, and the least fat; and that its properties regularly improve

improve to the last stage of milking; in this manner it is that milk-women procure creamy milk. It will therefore be attended with great advantage, both to the infant and the mother, to let the infant suck only at stated periods sufficiently remote from each other, in order that the homogenous milk may be entirely drawn out by the suckling, whose desire for it is then greater, and who exhausts the breast more completely.

#### B. *Milk of the Ass.*

70. The she-ass, when well fed and attended, affords milk always more fluid than that of the cow, the consistence of which more resembles that of the woman. It is in general not very palatable; it constantly affords a white soft butter, very liable to rancidity. Runnet, the acids, and all the well known means coagulate the asses' milk; its coagulum is commonly in a magma, one part of which floats upon the surface of the liquor, whilst another is precipitated. The serum is very easily clarified. It has not more, or very little more colour than that of woman's milk; it is a little less saccharine than the latter, but sensibly more so than the whey of cow's milk. Haller, however, indicates for the quantity of the mucofo-saccharine substance contained

contained in asses' milk, a greater proportion than for that of the woman. This proportion, according to him, is as 82 to 67 ; so that this liquor appears to be that which, of all, contains the most sugar of milk. Citizens Deyeux and Parmentier assure us, that by examining comparatively the milk of three asses, they found many varieties in the serum which they obtained from it. It appeared to them to contain the same salts as that of the cow, but in smaller quantity.

### C. *Goat's Milk.*

71. The milk of the goat is the thickest of all, according to the same chemists. It has a smell which is disagreeable to some persons, but which may be diminished by attention and cleanliness in the feeding of the animal : that of white goats is less odorous than that of black ones. It affords much cream, and this yields much butter. The butter of goat's milk is white, it acquires much solidity, and keeps for a long time without becoming rancid. The same milk also contains much caseous matter, which is easily separated from it by all the well known means. It is obtained in the form of a very dense, very thick curd. The serum of this milk may afterwards be well clarified ; it is generally yellowish, with a greenish cast. According



according to Haller, the proportion of the sugar of milk contained in it, with relation to that of cow's milk, is as 42 to 54; and according to citizens Deyeux and Parmentier, it does not contain less of it than the latter: but what has appeared to them very remarkable is, as they assert, that they found in it only muriate of lime, after having extracted from it the mucosaccharine matter. We should be led to believe that the phosphate of lime ought also to be abundant in it, from the thickness, the hardness, and the length of the hair of this animal, upon the nature of which, this salt has much influence, as I have already indicated in the article concerning the analysis of the hair.

#### D. *Ewe's Milk.*

72. Though at first sight this is little different in its aspect from the milk of the cow, it presents, however, in the analysis, especially in that made by citizens Deyeux and Parmentier, well-marked characters which distinguish it. It affords a cream which is abundant, but has little thickness, from which is separated a soft very fusible butter, of the consistence of a fixed oil, of a very pale-yellow colour, which easily becomes rancid. Its caseous matter is fat and viscid; its serum, which in general is difficult to be clarified, easily yields sugar of milk almost pure

pure from the first crystallization, according to the above-mentioned chemists. It is, however, of all kinds of milk, that which, according to the authors collected and compared by Haller, affords the least of this mucofo-faccharine substance; its proportion to that of the cow is as 37 to 54. The serum, after the extraction of this substance, contains muriate of lime in very small quantity, according to citizens Deyeux and Parmentier.

The most remarkable difference, or the most prominent character of the milk of the ewe, consists in the properties or consistence of its caseous part: its viscid and soft state is the cause of the fatty consistence which the cheeses prepared with it constantly present. On this account, it is the practice in some countries to mix ewe's milk with the milk of the cow and the goat, in order to give to the cheeses which are fabricated there, a more unctuous and marrow-like quality, and a softer paste, which does not dry without difficulty.

#### E. *Mare's Milk.*

73. This is the most fluid milk of all that have been mentioned. It has hardly any smell or taste. The small quantity of cream which it affords is very liquid, yellowish, and furnishes only, with difficulty, a small quantity of bad-conditioned butter; it seems that the caseous matter,

matter, which is difficult to be separated from this milk by the vegetable acids, remains adhering to the butter, for there remains a portion of it dissolved by these acids, as well as by the serum. However, this is easily clarified, and sugar of milk obtained from it by evaporation.

According to the extracts compared by Haller, mare's milk is the second in the order of the milks, with respect to the quantity of sugar which it yields; it follows immediately after asses' milk, and stands in the interval between this and the milk of women. The proportion of this muco-faccharine principle, relatively to that which cow's milk presents, is, according to this celebrated physiologist, as 70 to 54. It is known, that mare's milk, kept for some time, acquires an intoxicating quality, and it is in this milk that this property of vinous fermentation has first been observed.

*F. Materials of the different Milks compared with each other.*

74. By comparing, according to the details given relative to each milk in particular, the constant nature, more useful to be known than the variable proportion of the products extracted from them, the following results have been ascertained by citizens Deyeux and Parmentier by their investigations.

All

All the milks become covered with cream at their surface, but it varies in the different kinds of milk.

*a.* In the milk of the *cow*, it is abundant, thick, and yellow.

*b.* In *human* milk, more liquid, white, in small quantity.

*c.* In *goat's* milk, more abundant than in the milk of the cow, thicker, whiter, and especially less aced.

*d.* In *ewe's* milk, almost equally abundant and yellow as in that of the cow, but always distinguishable by a particular taste.

*e.* In *asses'* milk, not thick, little abundant, frequently similar to that of human milk.

*f.* In *mare's* milk, very fluid, similar in colour and consistence to good cow's milk, from which the cream has not yet separated.

75. The butter, is always oily, sweet, very fusible, and has the following comparative properties.

*a.* Extracted from the cream of the *cow*, it is sometimes very yellow, sometimes pale, frequently white, and always considerably consistent.

*b.* Difficult to be extracted from the cream of *human* milk, in small quantity, insipid, of a pale yellow colour, frequently inseparable from the cream, which it renders unctuous; whence it has been erroneously inferred that this milk affords no butter.

*c.* The

c. The butter of *asses'* milk is always very white, soft, very subject to speedy rancescence.

d. The butter of the *goat* separates easily from the cream, is very abundant, always white, firm, soft, and rancescible.

e. The butter of the *ewe*, is rather yellow, always soft, considerably subject to rancidity.

f. The butter of *mare's* milk is difficult to be obtained in small quantity, it does not assume consistence unless by washing in cold water, and is much disposed to rancidity.

76. The caseous matter is also a constant product, one of the constituent materials of milk; it varies in the species in the following manner.

a. That of the *cow* is voluminous, tremulous, seemingly gelatinous, very abundant, retaining much serum which is made to flow out by a slight pressure.

b. That of *woman's* milk is little abundant, without cohesion between its particles, always unctuous and stringy, retaining but little serum between its particles.

c. That of the *ass*, nearly similar to the preceding, without unctuousity.

d. That of the *goat*, in large quantity, in a thick coagulum, more dense than the curd of cow's milk, retaining less serum.

e. That of the *ewe*, always fat<sup>ly</sup> viscid, difficult to be condensed into curd, and giving a soft paste to the cheeses.

That

*f.* That of *mare's* milk little abundant and very similar to that of human milk.

77. The serum constitutes in general the most abundant part of the milks; it varies in the different species as follows :

*a.* The clarified serum of *cow's* milk is sometimes of a pale yellow, sometimes of a greenish colour, containing sugar of milk and salts.

*b.* That of *woman's* milk, is little coloured, of a very saccharine taste, being the third, according to Haller, with respect to the proportion of the mucofo-saccharine substance.

*c.* The serum of *asse's* milk is without colour, containing less salt and more sugar of milk than that of the cow.

*d.* The serum of *goat's* milk is scarcely yellowish, a little saccharine, holding the last place but one with respect to the quantity of saccharine matter, with few salts, almost solely the muriate of lime.

*e.* The serum of *ewe's* milk is almost always colourless, of a faint, and as it were greasy taste, the least charged with sugar of milk, containing muriate and phosphate of lime in small quantity.

*f.* The serum of *mare's* milk is little coloured, the second, according to Haller, with respect to the quantity of saccharine matter contained in it; according to Deyeux and Parmentier, charged with more saline matters than most of the other milks.

## SECTION VIII.

*Of the Uses of Milk.*

78. THE uses of milk are extremely numerous and always of great importance. They may be considered under the fourfold relation of natural uses, economical uses, medicinal uses and uses in the arts. Under the three first of these relations this alimentary and medicinal liquid constitutes the opulence of several whole nations wise in their simplicity, and happy enough in what we call their barbarism, to place their wealth in the abundance of their cattle, which furnish them with what they require for satisfying all their wants. The pastoral or erratic nations, who live almost entirely upon milk and its products, and the times in which a great number of those which are now civilized derived from it their simple nourishment, recal to our minds those happy days which the poets have depicted to us as the golden age, and it appears to the philosopher who compares those happy ages and people with those of the present day, that the mildness of this aliment of the first inhabitants of the earth, must have had an influence upon the gentleness and amenity of the manners of antiquity.

79. By swelling the mammæ of the mothers with milk immediately after parturition, nature has given to animals the two-fold advantage of a nourishment necessary to their young, and an evacuation useful to the mothers. The latter, after the abundance of the fluids which have long distended their uterine systems, find in the evacuation of the milk a discharge for those redundant fluids, whilst their young derive from it a support appropriated to their weakness, at first laxative, but afterwards becoming more and more nutritious, easy to be assimilated into their own substance, and containing, by an admirable institution of Providence, the solidifiable matter of their bones in a proportion corresponding with the rapid augmentation which these organs must experience during the first period of life. In this two-fold point of view, it is evident, that it is equally necessary to the mothers, after delivery, to evacuate this super-abundance of fluids, and to the young to nourish themselves with it: and that while the former cannot without danger renounce the suckling of their young, these likewise cannot be deprived of this aliment without inconvenience. Accordingly, severe, painful and frequently fatal diseases are the just punishment of mothers who renounce this duty, whilst a permanent weakness and languor throughout the whole of their lives, impend over the young animals that are deprived of this food.



80. Man must soon, and almost in the first ages of the world, have been led by observation to employ as food the milk of the animals which he has been able to tame and render subservient to his wants. Accordingly, the different alimentary preparations of milk are traced back to the most remote ages of antiquity. The abundance of milk lasts only for a season, or at least it is soon too much diminished to be sufficient for the supply of the wants of man; it was therefore necessary that means should be discovered for preparing it in such a manner that the superfluity of one period of the year might be kept to supply the deficiency of the others. Hence the different kinds of cheeses. The natural alterations which milk undergoes, being early observed, have also given rise to the great multitude of various aliments that are prepared with this liquid, especially cream, butter, curd, butter milk, sour whey, &c. The Tartars have long possessed the art of preparing intoxicating liquors with milk. Its employment as a seasoner, its mixture and combination with fruits, honey, sugar, the different infusions and decoctions, the vegetable perfumes which add more or less agreeable tastes and smells to the mildness and unctuousity of milk, were not contrived till long after the discovery of the products obtained from this liquid. Art has so much multiplied this preparation, that it would be useless to attempt their enumeration;

meration; besides which they vary in the different countries. Modern chemistry has added to the ancient economical uses of milk, that of converting it into vinegar, which in certain provinces may be an advantageous substitute for the acid furnished by wine, cyder, beer and the four fruits.

81. There are few medicinal substances that have been applied to such a multitude of uses by the physicians as milk. As a mild, relaxing, emollient, cooling substance, it is adapted to a great number of maladies. There are some even upon which it seems to exert a specific action, as the attacks of the gout, the rheumatism, obstinate herpetic eruptions, incipient depravation of the lungs, ulcerated affections of the urinary passages, &c. To this general and common action of all kinds of milk upon the animal economy, experience has shown that we may add the particular action of each species of milk: that the milk of the ass is the lightest and the most easily digested; that of the goat much heavier and adapted for strong and vigorous stomachs, and for those cases in which the body is to be nourished and invigorated; that the human milk, the sweetest and most saccharine, in which the caseous part is the most abundant, is on the contrary well adapted to weak stomachs and difficulty of digestion. Accordingly, it is with the intention of fulfilling these different indications that the physicians prescribe one or the other of the four  
kind

kinds of milk, the human milk, goats' milk, asses' milk and cows' milk. They have also thought fit to divide the milk and to dilute it with water, to prepare from it the whey or serum, and to administer it either sweet and clarified, or soured, to combine the different kinds of milk with different remedies, to soften or moderate their effects by this addition, or to favour the intromission of this liquid into the humours by giving it a little more activity, by correcting its insipidity, its weight upon the stomach, its occasional astringent effect, or on the contrary its relaxing operation. It is necessary that the physician should be provided with an accurate knowledge of chemistry, in order to be able to prescribe these mixtures and these combinations of milk with different medicinal substances without destroying the properties of the latter: thus he ought to know that lime water precipitates calcareous phosphate from it by passing itself into this state, that many metallic salts are decomposed in it, and that matters susceptible of acescence coagulate it. Lastly, the administration of milk in medicine has been carried so far, as to impregnate it with some medicinal properties by treating in different ways the animals that furnish it, or the nurse herself who suckles the infant.

82. The multiplied resources which the milk of animals affords under a thousand diversified forms, leave but little room for the use

use of these valuable liquids to arts not belonging to the nourishment of the body. However, though it be not much employed in the arts, it is however not without utility in this point of view. Milk that has become sour and turbid is frequently employed in the manufactories where fine cloths are dressed, in order to give them that beautiful white which is not improperly called milk-white. It is even believed in these manufactories that no other substance can be substituted for this lactic acid, though able chemists have maintained that the sulphuric acid diluted with water produces the same effect. Barrels filled with sour whey are sent from the rich mountains of Switzerland into France, for the purpose of being employed in this process of bleaching. I have elsewhere observed, that the caseous matter, kneaded fresh with lime, forms a tenacious paste, susceptible of hardening, which is employed for cementing broken porcelain together. Rancid butter is rendered subservient to a number of uses by the industry of the chemical arts: it is manufactured into soap, and other compounds.

END OF THE NINTH VOLUME.

